DETROIT SCIENTIFIC ASSOCIATION.

THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[THIRD SERIES.]

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ART. I. — *Results derived from an examination of the United States Weather Maps for* 1872 *and* 1873; by ELIAS LOOMIS, Professor of Natural Philosophy in Yale College. SECOND PAPER. With Plate I.

(Read before the National Academy of Sciences, Philadelphia, Nov. 3, 1874.)

Direction and velocity of the wind within areas of maximum pressure.

IN order to deduce from the weather maps the laws of the wind's motion within an area of maximum pressure, I proceeded in substantially the same manner as in the case of areas of low barometer, described in my first article, page 6 (see this Journal, July, 1874). I selected all those cases in which an area of maximum pressure, or high barometer, was so situated that the direction and velocity of the wind were given at a considerable number of stations for at least half of the entire area. Then placing a wire cross upon one of the weather maps over the center of an area of high barometer, with the wires pointing northeast and southwest, the area was divided into four quadrants, which are designated as the north, east, south and west quadrants. Then beginning with the west quadrant, I counted the number of stations at which the wind was reported from the north, also the number of observations from the northeast, the east, southeast, etc.; and in like manner for each of the four quadrants. The velocity of the wind for the stations of observation in the different quadrants was also noted. The same was done with each of the weather maps which furnished an example suited to this comparison. The total number of cases derived from the

weather maps of two years (1872–3) was 188. All the observations made near the point of maximum pressure were rejected; generally all the stations included with the first isobar. Also no observations were employed beyond the isobar 30·00, and generally none beyond the isobar 30·10. I then found by addition the aggregate number of observations for each direction of the wind in the several quadrants, and from these numbers computed the wind's average direction for each quadrant. The average velocity of the wind for each quadrant was also determined. The following table shows the resulting velocities and directions, and I have added a line showing the angle which the wind's direction makes with a radius drawn from the point of greatest pressure.

For high barometer.

	West quadrant.	South quadrant.	East quadrant.	North quadrant.
Velocity of wind,	5·22 miles.	6·02 miles.	6·48 miles.	6·13 miles.
Direction of wind,	S. 63° 0′ E.	N. 29° 55′ E.	N. 36° 59′ W.	S. 59° 15′ W.
Angle with radius,	27° 0′	29° 55′	53° 1′	59° 15′

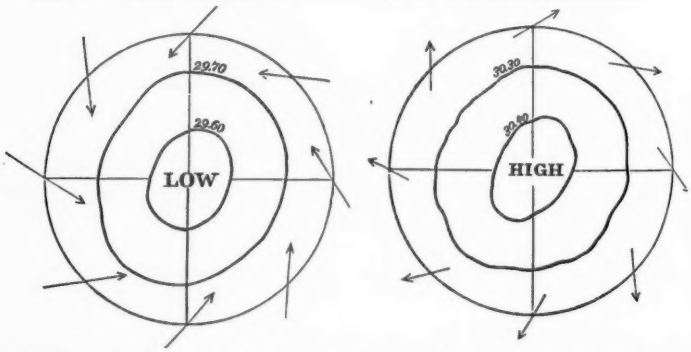
The importance of these results will be more apparent if we contrast them with the results obtained for areas of low barometer as given in my former article, pages 6–9. These results are as follows:

For low barometer.

	West quadrant.	South quadrant.	East quadrant.	North quadrant.
Velocity of wind,	10·1 miles.	8·8 miles.	8·3 miles.	7·6 miles.
Direction of wind,	N. 58° 48′ W.	S. 40° 25′ W.	S. 32° 6′ E.	N. 42° 33′ E.
Angle with radius,	31° 12′	40° 25′	57° 54′	42° 33′

In order to exhibit these results palpably to the eye, I have constructed the two following figures, in which the arrows at

No. 1. For Low Barometer. No. 2. For High Barometer.



the four cardinal points show the average direction of the wind according to the preceding tables, and the four intermediate

arrows show the direction at the corresponding points as interpolated from the first four numbers. The lengths of the arrows are proportioned to the velocity of the different winds.

From these diagrams it will be apparent that in each quadrant the direction of the wind for high barometer is nearly opposite to the direction in the same quadrant for low barometer, the differences in the several quadrants being as follows:

West quadrant.	South quadrant.	East quadrant.	North quadrant.
4° 12′	10° 30′	4° 53′	16° 42′

For high barometer the average angle which the winds make with radii drawn from the point of greatest pressure is 42° 18′; for low barometer the average angle which the winds make with radii drawn from the point of least pressure is 43° 1′. In each case, therefore, the wind's direction is almost exactly midway between a tangential and a radial movement, but approaching somewhat nearer to the latter.

In order to determine to what height above the level of the sea the law of movement shown in the preceding diagrams prevails, I discussed the observations made on the summit of Mt. Washington at an elevation of 6,285 feet above the level of the sea, in the same manner as I had already discussed the observations at the other stations, and obtained the following results:

For low barometer on Mt. Washington.

	West quadrant.	South quadrant.	East quadrant.	North quadrant.
Velocity of wind,	49 miles.	44 miles.	37 miles.	32 miles.
Direction of wind,	N. 55° 7′ W.	N. 76° 35′ W.	S. 53° 44′ W.	N. 20° 6′ E.
Height of barometer reduc. to sea-level,	29·54	29·60	29·76	29·76

For high barometer on Mt. Washington.

	West quadrant.	South quadrant.	East quadrant.	North quadrant.
Velocity of wind,	32 miles.	18 miles.	38 miles.	32 miles.
Direction of wind,	S. 14° 37′ E.	N. 4° 8′ W.	N. 54° 48′ W.	N. 57° 52′ W.
Height of barometer reduc. to sea-level,	30·28	30·21	30·03	30·11

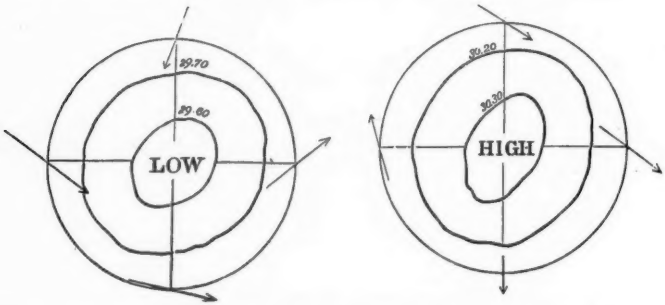
These results are graphically represented by the following diagrams, Nos. 3 and 4, in which, for convenience, the force of the wind is represented upon a scale only one-fourth as great as in the two previous diagrams.

The number of observations from which the results in Nos. 3 and 4 are derived is much less than for Nos. 1 and 2, and this will probably explain some anomalies which might be expected to disappear in the average of a greater number of observations.

A careful comparison of these diagrams will show that the winds represented in Nos. 3 and 4 correspond pretty well with what might be expected from the winds represented in Nos. 1

and 2 struggling against an upper current from some N.W. quarter. The average direction of the wind on the summit of Mt. Washington in 1873 was from N. 76° W. If we regard this

No. 3. Low Barometer on Mt. W. No. 4. High Barometer on Mt. W.



as the normal wind, and the winds shown in Nos. 1 and 2 to be disturbing forces tending to interfere with the normal wind, and we attempt to construct a triangle in which two of the sides shall represent these two forces, and the third shall represent the wind actually observed, we shall obtain a satisfactory construction in six out of the eight cases. In two cases the construction fails, viz., for low barometer in the west quadrant and for high barometer in the north quadrant, but a small change in the value of one of the angles would render the construction possible. These figures indicate that the average amount of the disturbing force is about equal to the normal force; in other words, the force of the winds shown in Nos. 1 and 2, at the height of 6,285 feet, is about equal to the force of the normal current which prevails at that elevation. It seems, therefore, reasonable to infer that at the height of 5,000 feet, the winds shown in Nos. 1 and 2 must generally be strong enough entirely to displace the normal current at that height.

It will be noticed that "for high barometer on Mt. Washington," the average height of the barometer was small, particularly for the east quadrant. But for the same dates, the average height at Burlington, Vt., was 30·35 inches, which suggests the idea that in those cases the reduction of the Mt. Washington observations to the level of the sea was too great.

A comparison of diagrams 1 and 2 cannot fail to suggest the idea that a high barometer must exert an important influence upon a neighboring low barometer. It will be noticed that when the high barometer is on the east side of the low barometer, both systems tend to impress nearly the same direction upon the wind at a point intermediate between them, and the

same is true upon whichever side of the low barometer the high barometer is situated. It seems natural to conclude that the result must be an increased steadiness and force of the winds in question. How far this conclusion is confirmed by the observations, and what may be its effect upon the direction and velocity of a storm's progress, I propose to consider hereafter.

Consequences of the outward flow of air from an area of high barometer.

We have found that from an area of high barometer there is an outward movement of the air having an average inclination of 42° 18′ to a line drawn from the point of greatest pressure. Near the surface of the earth, the average velocity of this movement is 5·96 miles per hour, but as we ascend above the surface, this velocity is very much increased. Suppose now that the area of high barometer is a circle 1,500 miles in diameter; that the barometer at the center of this area stands at 30·50 inches, and that the average velocity of the entire column of air is 18 miles an hour, which is the mean between the velocities observed near the level of the sea and on the top of Mt. Washington. Assuming that the average inclination to the radius is 42° 18′, we find the resolved portion of the wind's motion in the direction of radius is 13·3 miles per hour. What must be the effect upon the height of the barometer resulting from this outward movement from the area of maximum pressure, the flow being supposed to extend to the height of 5,000 feet? In less than three hours the barometer would be reduced to thirty inches, if there were no counter movement in the upper regions of the atmosphere. Now we know that these areas of high barometer have considerable permanence. It is quite common for them to remain nearly stationary for 24 hours; frequently they continue thus nearly stationary and without much change for 48 hours; and cases sometimes occur in which the barometer remains above 30·25 inches for four or five successive days and even longer. Thus from Dec. 29, 1872, to Jan. 2, 1873, the barometer at New Haven was never below 30·30; from Nov. 29 to Dec. 3, 1873, the barometer was never below 30·35; and from Dec. 31, 1873, to Jan. 6, 1874, it was never below 30·25.

These facts appear to me to prove that areas of high barometer are maintained by a continued accession of air in the upper regions of the atmosphere, and this accession is probably derived from the air which ascends near the center of an area of low barometer. In my former article, page 10, I have shown that near the center of an area of low barometer there is a strong *upward* movement. The facts which I have now presented appear to me to demonstrate that near the center of an

area of high barometer there is a *downward* movement, not generally violent, but steady and of long continuance. The result of such a downward movement must generally be a considerable fall of the thermometer at the surface of the earth. The atmosphere generally loses heat most rapidly at the top, in consequence of radiation into space, and it receives its heat chiefly at the bottom from the effect of the sun's rays upon the surface of the earth, so that at an elevation of a few miles a pound of air usually contains a less amount of heat than a pound of air near the earth's surface. Hence we conclude that within an area of high barometer the thermometer must generally stand below its mean height.

Monthly minima of temperature.

In order to test the preceding conclusion, I have taken the monthly minima of temperature as observed at New Haven for the years 1872, 3, and 4, and have compared them with the state of the barometer and such other circumstances as could be supposed to influence the result. These observations of temperature were all made with a self-registering thermometer. The precise hour of minimum is therefore unknown, but it occurred sometime during the night preceding the date given in column first. In the following table, column first shows the date of minimum temperature for each month; column second shows the lowest temperature recorded; column third shows the direction of the wind as recorded at the morning observation, which in summer was generally 6 A. M., and in winter about 7 A. M.; column fourth shows the degree of cloudiness at the same hour; column fifth shows the height of the barometer at New Haven; column sixth shows the position of the nearest center of high barometer as indicated by the U. S. weather maps; and column seventh shows the highest isobar represented on the map for the corresponding date.

Upon comparing these observations, we perceive that in all but five cases the sky at the date mentioned was cloudless, and in only two cases did the clouds cover as much as one-half of the sky. It is probable that in each of these cases, during a portion of the preceding night the sky had been entirely cloudless. We must conclude, then, that these monthly minima of temperature were in part the result of *radiation;* but this cause alone will not account for the very low temperature observed, for these observations were very much below the average temperature of the same months on cloudless nights. We find that in about two-thirds of the cases, New Haven was included within the area of a high barometer; that in several of the remaining cases an area of high barometer existed at the west and was rapidly approaching New Haven, although the barom-

eter at the latter place had not yet risen above 30 inches; and that in the few remaining cases there was at no great distance from New Haven an area of *relatively high* barometer, although the actual height of the barometer did not much exceed 30 inches.

Lowest temperature for each month at New Haven, Conn., for the years 1872, 3, *and* 4.

Date of minimum.	Min'm temp.	Wind.	Cloudiness.	Barom. N. H.	Center of high barometer.	Highest isobar.
1872. Jan. 31	4°·4	N.W.	0	30·25	Nashville.	30·50
Feb. 23	6·7	N.	3	30·07	Norfolk, Va.	30·10
March 5	−1·2	N.W.	0	29·95	Chicago.	30·30
April 18	28·1	N.	0	29·97	Near Long Island.	30·00
May 1	39·2	S.E.	3	30·26	Near New York.	30·30
June 2	48·2	N.	0	30·01	Lake Huron.	30·10
July 25	56·0	W.	5	30·08	Gulf of Mexico.	30·20
Aug. 31	54·0	W.	0	29·70	Illinois.	30·10
Sept. 4	43·3	N.	0	30·05	Pittsburg, Pa.	30·10
Oct. 30	29·3	N.E.	0	30·57	Maine.	30·60
Nov. 30	10·3	W.S.W.	0	29·75	Georgia.	30·50
Dec. 28	−20·0	N.	0	30·10	Nashville.	30·60
1873. Jan. 30	−26·0	N.W.	0	30·25	Pennsylvania.	30·30
Feb. 24	−6·0	W.	0	29·77	Nashville.	30·30
March 5	8·5	N.W.	0	30·53	Knoxville.	30·70
April 1	31·8	W.	0	30·08	Chesapeake Bay.	30·10
May 4	33·2	N.	1	29·96	Louisville.	30·10
June 1	46·3	W.	0	30·35	Chesapeake Bay.	30·40
July 19	55·0	N.W.	5	29·94	Halifax.	30·20
Aug. 24	51·0	N.	0	30·06	Lake Huron.	30·40
Sept. 15	38·0	N.	0	30·27	Washington, D. C.	30·20
Oct. 30	29·4	N.	0	30·47	New York.	30·40
Nov. 29	15·5	W.	0	30·47	Wheeling, Va.	30·60
Dec. 31	10·0	W.	0	30·33	Wilmington, N. C.	30·60
1874. Jan. 17	3·6	W.	0	30·43	Lynchburg, Va.	30·50
Feb. 2	−1·4	N.N.E.	0	30·72	Quebec.	30·80
Mar. 24	12·2	N.N.W.	0	30·32	St. Louis.	30·70
April 5	14·8	W.	0	30·44	Baltimore.	30·40
May 12	32·7	N.	0	30·52	Long Island.	30·50
June 14	46·3	N.N.W.	0	30·26	Washington, D. C.	30·30
July 4	57·0	S.	0	30·05	Charleston, S. C.	30·10
Aug. 29	50·9	N.	0	30·06	Gulf of St. Lawrence.	30·10
Sept. 23	43·5	N.W.	0	30·28	Baltimore.	30·30
Oct. 15	32·0	N.	0	30·41	Virginia.	30·50
Nov. 14	19·1	N.	0	30·67	New York.	30·70

The preceding considerations appear to me to prove that the extremely low temperatures which occur at irregular intervals in every month of the year, but particularly in the winter months, are due mainly to the descent of cold air in the neighborhood of an area of high barometer; and this descent of the air results from the outward movement which generally takes place from the center of an area of high barometer.

Long continued periods of cold weather.

Sometimes we have a period of severe cold continuing ten days or even longer. The most remarkable cases of this kind

within the last three years took place between Dec. 22, 1872, and Feb. 3, 1873. The following table shows the most important particulars respecting two periods of this description as observed at New Haven.

Date.	Max'm temp.	Min'm temp.	Barom. 7 A.M. N. H.	Wind. N.H.	Cl'di-ness.	Center of high barometer.	Highest isobar.	REMARKS.
1872.								
Dec. 21	34·2	24·7	30·16	N.N.W.	3	Nebraska.	30·70	Pleasant day.
22	17·5	11·3	30·12	N.N.W.	0	Kentucky.	30·60	1 in. of snow last night.
23	29·4	−0·9	30·11	S.W.	10	Georgia.	30·30	Snow ceased at 10 A.M. Amount, 3½ inches.
24	17·4	8·7	30·40	N.W.	10	Illinois.	30·70	Pleasant afternoon.
25	16·2	−1·5	30·53	N.	5	N. Hampshire.	30·60	Pleasant day.
26	8·8	−1·0	30·06	N.N.E.	10	Montreal.	30·20	Snowed all day till 9 P.M. Am't, 15 in.
27	14·4	4·8	29·72	N.	10	Nebraska.	30·70	Cloudy all day.
28	28·3	−11·7	30·12	N.	0	Tennessee.	30·60	Pleasant day.
29	27·3	6·2	30·34	N.W.	10	Georgia.	30·50	Cloudy all day.
30	24·3	0·2	30·53	N.N.W.	0	N. Carolina.	30·60	Pleasant day.
31	29·3	10·4	30·28	N N.E.	10	Georgia.	30·40	Snow till 4 P.M. Am't, 3 inches.
1873.								
Jan. 1	30·4	8·5	30·42	N.	0	Albany.	30·40	Fine.
2	20·6	3·3	30·45	N.	0	Maine.	30·50	Cloudy afternoon.
26	27·2	7·5	30·25	N.	10	Baltimore.	30·20	Slight snow in forenoon.
27	26·0	19·3	29·99	N.E.	10	Dacotah.	30·40	Snow all day. Am't, 6 in.
28	33·0	15·0	30·06	S.W.	0	Nebraska.	30·80	Fine.
29	12·2	0·0	30·35	N.W.	0	Indiana.	30·50	Fine.
30	20·4	−16·8	30·25	N.W.	0	Pennsylvania.	30·30	Fine.
31	34·2	6·3	30·15	N.W.	0	Dacotah.	30·50	Fine.
Feb. 1	33·8	9·7	30·10	N.W.	0	Nebraska.	30·70	Fine.
2	17·5	2·8	30·30	N.N.W.	0	Illinois.	30·60	Fine.
3	35·5	6·2	30·25	S.W.	4	Charleston.	30·30	Snow from 2½ P.M. to [evening.

Column second shows the highest temperature and column third the lowest temperature observed at New Haven on each of the days named in column first; column fourth shows the height of the barometer, column fifth the direction of the wind, and column sixth the amount of cloudiness observed at New Haven at 7 A.M.; column seventh shows the position of the nearest center of high barometer, and column eighth the highest isobar drawn on the U. S. weather map for the corresponding date; column ninth shows some miscellaneous particulars recorded at New Haven.

It appears from the preceding table and from a comparison with the U. S. weather maps, that during the period above named there was an area of high barometer of unusual extent, which covered nearly the whole of the United States east of the Rocky Mountains and generally included New Haven. The only exceptions are near Dec. 27th and Jan. 27th. But at each of these dates an unusually high barometer prevailed at the same time at a great distance west, and its influence was felt

not only at places where the pressure was above 30 inches, but also at places where the barometer had not yet reached the height of 30 inches. I conclude, therefore, that the severe cold which prevailed at this period throughout the United States east of the Rocky Mountains was mainly the result of cold air descending from the upper regions of the atmosphere under the influence of a high barometer.

The only other explanation of this phenomenon which I think can be plausibly urged, is that this cold was the result of a current of air sweeping along the surface of the earth from a very high northern latitude, and bringing with it the low temperature of the region from which it came. I admit that during the period in question northerly winds were unusually prevalent, but these were winds attending high barometer in accordance with the laws which have been already established. I admit also that when there is a general drift of the atmosphere from north to south over an extensive area it must bring with it a reduction of temperature, but I am satisfied that this cause alone will not account for the suddenness and magnitude of the depression in the present case. From the 21st to the 22d of December, the mean temperature at New Haven fell 15°, and it continued at about this point or even lower for nine successive days. Was there at this time a steady flow of air from the Arctic regions sufficient to account for this effect? I am unable to appeal to my weather maps for an answer to this question, for, unfortunately, on these days, the observations from most of the stations in the extreme northwest are wanting, and if it were otherwise, it might appear that the maps did not extend far enough northward to furnish all the information which was required. If our observations covered the whole area of North America, I have little doubt we should find that the depression of the thermometer below its mean height was greater in the United States than it was in the region north of us, as I have shown was the case in the storm of Dec. 20, 1836, of which the investigation was published in vol. xi of the Smithsonian Contributions to Knowledge.

Storm of Jan. 6–8, 1874.

In the absence of adequate observations from British North America, it may be more satisfactory to take an example of a storm in the southern part of the United States, in which case the weather maps will inform us of the condition of the atmosphere on the northern margin of the storm. For this purpose, I have selected the storm of Jan. 6–8, 1874, which came up from the Gulf of Mexico and crossed the United States in a direction about N. 30° E. The following table shows the observations of the thermometer at $7^h\ 35^m$ A. M., from Jan. 4 to

Jan. 9, 1874, at all the southern stations of the Signal Service and most of the northern stations. These observations were copied from the weather maps and forwarded to the chief sig-

Observations of the thermometer at 7h 35m A. M., Jan. 4–9, 1874.

	Mean Temp. Jan'y.	Thermom. at 7h 35m A. M.						Above or below mean temp.					
		Jan. 4.	Jan. 5.	Jan. 6.	Jan. 7.	Jan. 8.	Jan. 9.	Jan. 4.	Jan. 5.	Jan. 6.	Jan. 7.	Jan. 8.	Jan. 9.
Indianola,	55°	49°	35°	34°	38°	41°	52°	− 6°	−20°	−21°	−17°	−14°	− 3°
Galveston,	55	52	39	34	43	48	55	− 3	−16	−21	−12	− 7	0
Key West,	68	70	66	68	68	62	57	+ 2	− 2	0	0	− 6	−11
Punta Rassa,	62	68	64	62	63	50	44	+ 6	+ 2	0	+ 1	−12	−18
New Orleans,	55	65	50	38	35	38	58	+10	− 5	−17	−20	−17	+ 3
Mobile,	52	58	48	43	33	32	50	+ 6	− 4	− 9	−19	−20	− 2
Lake City,	55	59	64	64	45	30	30	+ 4	+ 9	+ 9	−10	−25	−25
Jacksonville,	56	57	62	65	55	38	35	+ 1	+ 6	+ 9	− 1	−18	−21
Shreveport,	47	42	30	39	36	40	43	− 5	−17	− 8	−11	− 7	− 4
Montgomery,	48	53	54	48	35	32	44	+ 5	+ 6	0	−13	−16	− 4
Savannah,	52	60	59	64	51	36	37	+ 8	+ 7	+12	− 1	−16	−15
Charleston,	50	58	61	59	55	36	37	+ 8	+11	+ 9	+ 5	−14	−13
Augusta,	47	60	63	64	43	33	31	+13	+16	+17	− 4	−14	−16
Wilmington,	47	58	61	64	58	40	39	+11	+14	+17	+11	− 7	− 8
Fort Gibson,	40	15	11	21	22	31	30	−25	−29	−19	−18	− 9	−10
Memphis,	40	58	24	31	29	35	52	+18	−16	− 9	−11	− 5	+12
Nashville,	37	61	28	35	28	26	42	+24	− 9	− 2	− 9	−11	+ 5
Knoxville,	35	38	38	43	33	29	31	+ 3	+ 3	+ 8	− 2	− 6	− 4
Louisville,	33	61	25	32	29	25	38	+28	− 8	− 1	− 4	− 8	+ 5
Cincinnati,	31	60	30	33	32	28	38	+29	− 1	+ 2	+ 1	− 3	+ 7
Norfolk,	37	57	61	43	64	42	36	+20	+24	+ 6	+27	+ 5	− 1
Lynchburg,	33	54	56	37	59	37	32	+21	+23	+ 4	+26	+ 4	− 1
St. Louis,	32	33	12	21	22	33	38	+ 1	−20	−11	−10	+ 1	+ 6
Washington,	34	60	53	35	65	43	41	+26	+19	+ 1	+31	+ 9	+ 7
Cape May,	33	46	48	43	50	43	38	+13	+15	+10	+17	+10	+ 5
Baltimore,	33	47	51	38	56	44	35	+14	+18	+ 5	+23	+11	+ 2
Keokuk,	27	13	8	11	16	28	30	−14	−19	−16	−11	+ 1	+ 3
Omaha,	20	− 2	9	16	22	27	30	−22	−11	− 4	+ 2	+ 7	+10
Pittsburgh,	29	65	30	35	41	33	35	+36	+ 1	+ 6	+12	+ 4	+ 6
Philadelphia,	32	52	48	36	57	45	35	+20	+16	+ 4	+25	+13	+ 3
New York,	30	48	47	35	53	47	33	+18	+17	+ 5	+23	+17	+ 3
Chicago,	26	35	15	17	25	27	34	+ 9	−11	− 9	− 1	+ 1	+ 8
Cleveland,	28	60	31	33	33	30	37	+32	+ 3	+ 5	+ 5	+ 2	+ 9
Buffalo,	27	57	27	26	32	34	33	+30	0	− 1	+ 5	+ 7	+ 6
Boston,	27	47	49	32	34	55	34	+20	+22	+ 5	+ 7	+28	+ 7
St. Paul,	14	− 3	6	17	12	21	23	−17	− 8	+ 3	− 2	+ 7	+ 9
Breckenridge,	10	−20	0	12	16	18	9	−30	−10	+ 2	+ 6	+ 8	− 1

nal officer at Washington, by whose direction they were compared with the official records, the errors were corrected and the omissions in the daily weather maps supplied. From Jan. 1st to Jan. 5th a storm traveled entirely across the continent from west to east, the center of the storm passing over Lake Superior. This storm was followed by unusually cold weather, as is shown in the observations of Jan. 4th at Breckenridge, St. Paul, Omaha, Fort Gibson, Keokuk, &c. On the 5th of January

another and entirely distinct storm prevailed in the Gulf of Mexico; on the 6th it passed over Georgia; on the 7th it passed over Virginia, and on the 8th it passed north of Lake Ontario. This storm was followed by an unusual reduction of temperature in the southern States. Its effects were to some extent blended with those of the preceding storm, yet the effects of the latter can be distinctly traced, especially in the neighborhood of Florida. In the second column of the preceding table, I have given the mean temperature of January for each of the stations in column first; columns 3–8 show the observations of the thermometer at $7^h\ 35^m$ A. M.; and columns 9–14 show the differences between the observed temperatures and the mean temperature of January. The observations for January 8th are graphically represented on the accompanying chart, plate I. where the curve which passes through Mobile connects all those places where the depression of the thermometer was 20° below the mean; the curve which passes between Charleston and Savannah shows a depression of 15° below the mean; the curve passing near Nashville shows a depression of 10°; while the curve passing near Cincinnati connects those places having the mean temperature of January. Everywhere south of this line the temperature was below the mean; and everywhere north of this line the temperature was above the mean. It will be noticed from the table that on the 8th, in northern Florida, the depression of the thermometer was greater than it had been on either of the preceding days at Knoxville, Nashville, Cincinnati, Louisville and Memphis. This fact, together with the form of the isabnormal curves (convex toward the north), indicates that the cold did not come from the north or northwest, but must have descended from the upper regions of the atmosphere over the southern States.

There are other considerations of a more general nature which appear to me entirely conclusive with reference to the general principle which I have been trying to establish. The phenomenon in question is not peculiar to the United States, but prevails far to the north of us, even to the coldest regions which have ever been visited by man. It was found at Melville Island, lat. 75° N.; it was found at Van Rensselaer Harbor, lat. 78½° N.; it is found in the coldest parts of Siberia. At Melville Island, on the 26th of December, 1819, during a strong wind, the barometer fell to 29·10 inches; it soon began to rise, and in four days it rose to 30·75, the highest point attained during the year. During the same time the thermometer fell from −5° to −43°; the lowest temperature observed during the year. At Van Reusselaer Harbor, on the 28th of December, 1853, during a severe gale, the barometer fell to 29·05, and in two days it rose to 30 50. The thermometer during the same

time fell from +16° to −22°. At Jakutsk, in Siberia, lat. 62°, the mean temperature of January is −44° Fahr. But on the 21st of January, 1838, the thermometer fell to −76° F., or 32° below the mean temperature of the season. Now according to Dove's charts, there is no place on the earth's surface where the mean temperature of the coldest month is much below that of Jakutsk. What can cause such an extreme depression of the thermometer at the coldest point of the earth's surface? I think we are shut up to the conclusion that this unusual cold results from the descent of the upper atmosphere to the surface of the earth. If this is the true explanation of periods of unusual cold in Siberia, a similar phenomenon in the United States is doubtless to be explained in like manner.

The *suddenness* of these changes of temperature is sometimes more remarkable than their magnitude. On the 21st of December, 1836, the thermometer at Albany fell 18° in one hour, from 11 A. M. to noon. Allowing for the usual diurnal change of temperature, this indicates an absolute change of temperature of 20° in one hour, being the effect of a severe storm then in progress. In summer, during a thunder shower, it is not unusual for the thermometer to fall 5° or even 10° in a few minutes. Now an examination of the weather maps will show that this phenomenon is local. There is no cold stream of air flowing down from the northern regions to produce this sudden change of temperature, but the effect takes place along the track of a storm, which generally follows nearly a parallel of latitude, with, however, a slight inclination northward, that is, from a warmer to a colder region. These sudden gusts of cold air are believed to descend from the upper regions of the atmosphere.

Connection between the velocity of the wind and the distance between the isobars in the neighborhood of a storm center.

In order to determine the connection between the velocity of the wind and the distance between the isobars, I ruled a large sheet of paper with 40 vertical columns, and placed at the head of the columns the numbers 0, 1, 2, 3, etc., to denote velocity of the wind. Each weather map was then examined for observations suited to the present object. In the selection of stations the following rules were adopted: 1. All the observations within the first isobar about a storm center were omitted. 2. No observations were employed beyond the isobar 29·90, and when any station within these limits seemed to be under the influence of another storm center that observation was rejected. All the observations made on Mt. Washington were rejected. For each station which satisfied the above conditions the perpendicular distance between the two adjacent isobars was

measured, and the distance recorded under the corresponding velocity found at the top of one of the vertical columns. All the weather maps for 1872 and 3' were examined in this manner, and the distance between the isobars recorded. The following table shows the average results:

Relation between the velocity of the wind and the distance between the isobars.

Veloc. miles.	No. of Obs.	Mean distance	Av. distance	Dist. in miles.	Veloc. miles.	No. of Obs.	Mean distance	Av. distance	Dist. in miles.
0	69	·79	--	---	20	76	·63	·61	95
1	55	·90	--	---	21	9	·56	·62	97
2	81	·90	·86	134	22	23	·65	·62	97
3	53	·87	·86	134	23	13	·65	·62	97
4	176	·83	·84	131	24	40	·59	·62	97
5	111	·82	·82	128	25	13	·65	·61	95
6	168	·80	·80	125	26	5	·56	·59	92
7	80	·76	·79	123	27	5	·59	·58	90
8	230	·78	·78	122	28	20	·56	·54	85
9	65	·77	·76	119	29	4	·54	·54	85
10	129	·77	·75	117	30	15	·46	·52	81
11	56	·71	·74	115	31	4	·54	·50	78
12	262	·72	·73	114	32	7	·51	·48	75
13	34	·74	·69	109	33	0	--	·46	72
14	93	·70	·68	106	34	1	·44	·44	69
15	42	·60	·67	104	35	4	·39	--	--
16	122	·64	·64	100	36	4	·39	--	--
17	26	·65	·62	97	37	0	--	--	--
18	66	·60	·62	97	38	0	--	--	--
19	10	·60	·61	95	39	0	--	--	--

Column first shows the velocity of the wind in miles per hour; column second shows the number of observations corresponding to each velocity; and column third shows for each velocity the average distance between the isobars expressed in decimals of an inch. It will be noticed that the numbers in column second are very unequal; the number of observations for velocities 4, 8, 12, 16, 20, 24 and 28 being much greater than for the intermediate velocities. This shows that the velocities are not reliable within 1 or 2 miles, and this probably explains in part the irregularity of the numbers in column third. In order to smooth down these irregularities, I have taken the average of each sucessive five numbers in column third and set down the result in column fourth. The numbers in column fourth may, therefore, be regarded as exhibiting the results of the observations freed from some of the sources of error which affect individual observations. In column fifth, these distances are expressed in miles. This last column of numbers represents, therefore, the average distance between isobars (drawn at intervals of one-tenth of an inch) corresponding to the velocities given in column first. The average distance of the stations of observation from the center of low barometer is

estimated at 350 miles. The numbers in column fifth are therefore regarded as representing for the United States the average distance between the isobars corresponding to the velocities in column first, at an average distance of 350 miles from a storm's center. We thus see that the average distance between the isobars is twice as great for the lowest velocity as it is for the highest velocity, so that the distance between the isobars affords some indication of the velocity of the wind, but the individual observations present so great anomalies that it is only the average velocity of the wind which can be safely inferred from the distance between the isobars. The great irregularities noticed in the individual observations are doubtless to be ascribed in part to the obstructions to the wind's motion arising from the inequalities of the earth's surface. Over a large expanse of water the distance between the isobars must afford a much more reliable indication of the force of the wind.

In preparing the materials for the preceding article, I have been assisted by Mr. Edward S. Cowles, a graduate of Yale College of the class of 1873.

ART. II.—*On some Points in the Geology of the Blue Ridge in Virginia;* by WM. M. FONTAINE.

PROFESSOR H. D. ROGERS, in the first volume of his Pennsylvania Reports, in giving a description of the strata lying along the lower Susquehanna, was at first positively of the opinion that this great body of slates is of Silurian age. He accordingly described this system as "altered primal upper slates." Since the publication of his first volume he announced the opinion that this section contained two, and perhaps more, series of unconformable strata, one of which is older than the Silurian, being perhaps equivalent to the Huronian of Canada.

This series of slates and quartzites passes south through Maryland into Virginia, where it attains great breadth and occupies the larger part of the State. It passes entirely across the State, having the Blue Ridge Mountains on its western border and the gold belt of this section on the east.

I had an opportunity, some time since, to examine in some details a part of the western portion of this belt, and propose to give in this paper a concise account of some of the geological features there seen. My detailed examination was confined to the Blue Ridge, and to the parallel chain running some twenty miles east of it. I also studied, with less minuteness, portions of the valley between them.

The Blue Ridge at Harper's Ferry is a single chain, but in passing southwest it expands, so as to embrace a portion of the silurian rocks on the west, and also a considerable area of the more altered rocks on the east, until in some parts it is formed of several parallel, short ranges, composed of slate of very different character and age. Thus, according to the locality examined, one would find the main chain composed of argillites of seemingly very ancient date, or of coarse syenites, or again of Silurian quartzites.

The lower chain on the east leaves the immediate vicinity of the Blue Ridge in Maryland, diverging more and more as it passes through Virginia, so as to embrace a belt of the country which widens to the south. This chain has a variety of names, according to the locality. In Maryland and Northern Virginia it is called "Catoctin," but farther southwest in Virginia, "Bull Run." It is then broken up into a number of isolated mountains for a considerable distance, reappearing as the "Southwest," and "Green Mountains," in Albemarle County. Near Lynchburg, Va., it is called "Buffalo Ridge;" and southwest of this place, it is again dispersed into isolated ridges and peaks. For the sake of convenience, I shall call this entire range by its more northerly name, "Catoctin."

The valley between these ranges presents its simplest topography to the north. It is there occupied mainly by isolated hills of considerable magnitude and by some connected chains of the same. Farther to the southwest, mountains both isolated and in short ranges appear in the central portions. Near Charlottesville, Albemarle County, these attain considerable dimensions and continue with increasing force to beyond Lynchburg, a distance of more than sixty miles. Near Lynchburg the valley obtains its maximum width of about twenty-five miles.

The most northerly portion of this belt examined by me was at "Point of Rocks," Maryland, and at "Harper's Ferry." In order to give some idea of the portions of the entire belt not examined by myself, I shall quote from Professor Wm. B. Rogers' Virginia Reports; all the more freely, as they unfortunately never have been published.

At Point of Rocks, on the Baltimore and Ohio Railroad, we have a splendid exposure of the rocks, both in the tunnel through the mountain and in the cuttings for the canal. The rocks composing the Catoctin Mountains here are, in their least altered condition, well defined argillites. This particular variety forms a very important feature in the geology of the northern part of the Blue Ridge. Its lithological features are so pronounced that it can be traced with ease as far as Rockfish Gap, west of Charlottesville, but with greatly diminished breadth there. Here in the north, it occupies almost the entire space of twelve

miles between Point of Rocks and Harper's Ferry. It forms also the most of the Blue Ridge at the latter place. Throughout this entire distance this rock shows a high southeast dip (45°), and evidently lies in a series of closed folds. The following is the normal character as presented throughout the district: Texture, fine, amorphous, to sub micaceous; color, dark gray, sometimes greenish, from films of chlorite. Cleavage usually obscured by consolidation, but parallel to the bedding. It occurs in more or less massive layers, often cut by joints, and is usually harder and denser than ordinary roofing slate. At Point of Rocks the following modifications are seen:

Commencing at the east entrance of the tunnel, we have the normal slates dipping 45° southeast; more toward the center intense local metamorphism appears. Here we find both cleavage and bedding lost, and finally see a massive structureless rock, but little harder than the true slates and of sub-micaceous texture; the particles being confusedly mingled and forming a substance not unlike some igneous rocks. This central portion is of a deep green color, from the great development of chlorite. It often has nests of epidote, sparingly disseminated and associated with knots and irregular veins of quartz. The quartz is very abundant. Some triclinic feldspar occurs in seams; and specular iron in brilliant, disseminated scales. Pyrite is quite common. This central, highly altered portion, has plainly been sufficiently softened to be capable of motion like a fused mass. It has been thrust up along the plane of bedding to the northwest. This is shown by the disturbance produced in the enclosing strata next to it, and also by the crumpling and bending of the slates on the west side. At the west end of the tunnel, where we have the normal slates again, these are thrown into abrupt sigmoid flexures, indicating such a motion of the central mass.

I have little doubt but that this peculiar effect is due to the crushing of the beds in the center of a synclinal fold. But the existence of a closed synclinal alone will not account for the very general occurrence of such features, throughout so much of the northern Blue Ridge, and almost everywhere along the long ranges of the Catoctin. There must have been fractures and lines of weakness of great extent in the direction of these mountains; for we find in them true igneous rocks also, especially in the Blue Ridge.

The rocks occupying a belt of two and a half miles in width, on the west of the Catoctin, exhibit along one or two lines the same features of metamorphism that are to be seen at Point of Rocks, but on a smaller scale. In each case we find this increase of local change along certain belts to be marked by ranges of hills commanding the country around. The Catoctin

Mountains, these hills, and the Blue Ridge at Harper's Ferry, are each the result, in part, of such local changes producing elevation, but mainly of unequal erosion. The normal slates have been eroded to a much greater extent than the more highly metamorphosed rocks, and these latter have been left standing up in connected ridges.

The entire distance from Point of Rocks to Harper's Ferry, on the Maryland side, is apparently occupied by the argillites. Professor Wm. B. Rogers states, however, that on the Virginia side a narrow tongue of gneiss is found at the eastern base of "Short Hill," near the center of the tract. This is the northern termination of a triangular area of gneiss which passes through Virginia along the eastern base of the Blue Ridge. A narrow belt of steatite and serpentine is also found in Loudon County, along with elliptical bands of magnesian limestone, which sometimes assumes the aspect of true marble. These latter rocks also pass southwest through the State in the belt in question. Professor Rogers describes the curious occurrence of the limestones. They resemble huge flattened concretions, being entirely enclosed in hydromica or talc slates, and apparently pass into them by insensible gradations.

Resuming our detailed investigations at the eastern base of the Blue Ridge on the Maryland side, at Harper's Ferry, we still find the argillites forming the principal rock, and here also inclosing a core of metamorphic matter, which seems to be entirely formed out of the slates. This rock does not correspond exactly with any described in lithology, and I am at a loss to name it in the absence of any analysis of the materials. As it appears to be largely present throughout the State along the eastern base of the Blue Ridge, preserving a pretty constant position about two and a half miles from the Silurian strata, it merits a detailed description. I think it is one of the rocks called by Professor Rogers "greenstone."

This rock is seen with its most pronounced features at the bridge-head on the Maryland side, forming the perpendicular rugged mass which gives to the pass its most striking features. It is a massive rock in structure, having all the features of an eruptive igneous material. The principal component is a greenish-gray, rather waxy-looking amorphous base, having a hardness of two and a half, and a somewhat greasy feel. Imbedded in this material occur rounded shot-like particles of quartz as large as a garden pea. They have various colors, pink, bluish, and white, the former predominating. The luster of the quartz is waxy. The nodules sometimes almost disappear and sometimes form the larger portion of the mass. The rock has evidently been in a state of partial liquidity, and been thrust up along the plane of dip to the northwest. It often con-

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tains enclosed fragments of argillites, sometimes little changed, and sometimes impregnated with chlorite, or with the mineral owenite, which is one of the metamorphic associates of this rock. Width about three hundred feet. Traced from the bridge-head eastward, it is seen to pass gradually into unequivocal argillite, the quartz particles diminishing, and the base assuming more and more the laminated, slaty structure of the argillites. This portion of the argillites seems to have been involved in the upheaval of the mass, for it is cut up by joints into angular masses, much penetrated by irregular nests and seams of quartz, and is without bedding. A little farther east, just outside of this, we find a curious modification of the metamorphic rock. It here appears in the form of dykes, which thrust off the slates in arches. This rock is almost entirely composed of quartz, with a little of the amorphous matter present, which gives the stone a green color. Both this modification and the normal rock form an exceedingly tough and durable material, which by its indestructible nature has preserved the mountain from erosion.

The above described rock, in weathered specimens especially, might be mistaken for a species of conglomerate; and I think has been so described by H. D. Rogers, in his account of the South Mountains of Adams County, Pa. From the resemblance of its base to a variety of *Pinite*, and for lack of a better name, I shall call it "pinite porphyry," although it is not a true igneous rock. Farther east we find argillites in heavy masses, penetrated with quartz, and leaning against the ridge with a dip of about 50° southeast.

To the west, up stream, for two miles to the east limit of the Silurian, we have normal argillites preserving a predominating southeast dip. Close to the pinite porphyry the slates are thrown into such abrupt flexures that they are rolled into cylindrical masses, which are penetrated by numerous quartz seams. More to the west several short rolls occur, all denoting a thrust to the west on the part of the metamorphic rock. The line of junction of the argillites with the Silurian is sharply marked, and no passage of one into the other occurs, although the southeast dip is preserved.

My next investigations were made along the line of the Chesapeake and Ohio Railroad near Charlottesville, and at Rockfish Gap, where this road crosses the Blue Ridge by a tunnel seven-eighths of a mile long, affording a splendid section of the strata. Before passing to this, a short description, derived in part from Rogers' Virginia Reports, must be given of the intervening country, for in this important modifications occur. They are as follows: The argillites diminish, and are confined to the immediate vicinity of the Blue Ridge. Quartzites of various natures

appear along the eastern border, and form the Catoctin to the southwest. These rocks in the north are the micaceous, slaty quartzites which form the Bull Run Mountains. To the southwest they become coarser, and by the assumption of a greater or less amount of feldspar, form gneissoid quartzites, or conglomerates. A schistose, argillaceous variety also appears here, much impregnated with chlorite and epidote, from its vicinity to the metamorphic rock, similar to that at Point of Rocks. Igneous rocks (not described) occur in the Blue Ridge near Swift Run Gap. Commencing on the east of the Catoctin range, we have the following rocks: 1st, Limestones, 2d, quartzites, and 3d, epidosites. These are usually associated, and the second form the mass of the Catoctin. These mountains in this region are usually composed of quartzites, while the limestones occur to the east of them. In the valley we find that from east to west steatites, hydromica slates, mica* slates, mica schists, and gneiss appear in the order named, so as to usurp the space which more to the north was occupied by argillites. The amount of epidote produced by concentrated local metamorphism along the line of the Catoctin is so much increased, that the partially fused rock, according to Rogers, is now a true epidosite, and seems to have invaded the quartzites and impregnated them with epidote and chlorite, just like a true igneous rock. This change may be due partly to the fact that the argil lites, which seem to be the source of the epidotic and chloritic products, are more deeply buried in this region. There is reason to think that the quartzites and associated rocks overlie the argillites here; hence the disappearance of the latter rocks.

We have seen that at Harper's Ferry the metamorphic products are principally quartzose. The case is different to the southwest, along the Blue Ridge. For much of the distance occupied by these mountains in this intermediate space, but especially near Swift Run Gap, and through the counties of Green and Madison, we find the argillites forming the main mass of the mountains highly impregnated with epidote, chlorite, quartz and other metamorphic products. At the same time, impregnations of various compounds of copper are found at numerous points here. As I did not visit this region, I cannot speak more definitely of it. The increased variety of meta-

* I have in this article used the terms *mica slate* and *mica schist* to denote different rocks. The former has slaty cleavages, is thinly laminated and fragile, having an amorphous to sub-micaceous texture, with a composition almost wholly formed of micaceous matter. The *mica schists* are stronger, heavier-bedded rocks, with quartz and micaceous matter in about equal proportions, and both appearing in visible individual particles. It is noteworthy that in no case is either constituent developed into large individuals. Thus the schist here differs much from that of the region adjacent to the Richmond granite, where both quartz and mica form large particles and produce a rock much like the mica schist of New York Island.

morphic products is no doubt due to the presence of true igneous rocks in this region. Rogers mentions their existence, but does not describe them.

The Chesapeake and Ohio Railroad crosses the Catoctin Mountains (here called "Southwest") about two miles east of Charlottesville, at Shadwell, which is situated on the Rivanna River. The stream has cut a passage through the range, exposing the rocks in its bed. The structure here is essentially the same with that seen at Point of Rocks. A series of closed folds give a succession of southeast dips. The material composing the mountain, however, is no longer argillite, but a more massive argillaceous quartzite, of greenish color, from the great amount of chlorite and epidote developed in it. This mass, when more highly altered, resembles very closely a true igneous rock, and is the material called by Rogers "epidotic rock." In passing out of the region of argillites of the north into the quartzites of the more southern district, we note thus a change in the structure of the Catoctin with respect to the nature of the strata. We still find a metamorphic product like that at Point of Rocks, only here with much more epidote. This, however, does not form any portion of the higher ground, called mountains in this section, but lies a short distance west of it, acting as the disturber and metamorphoser of the quartzite, which usually composes the mountains. The latter rock generally dips away from the epidosites (as we may call them), or stands vertically, and by its superior hardness has resisted erosion better.

The railroad crosses the valley nearly at right angles to the strike. By following it we get a tolerably good exposure of the strata. Just west of Charlottesville the first of a series of ledges of syenite is crossed. This rock, which abounds throughout the central portion of the valley, as far as Lynchburg, distant sixty miles, will be described in the account of the strata at that place.

The succession of rocks mentioned above as met with in going from east to west, in the district to the northeast of Charlottesville, occurs here also. We find, however, more abundant quartzites, and these of gneissoid character, extending farther west of the Catoctin range into the central parts of the valley. These quartzites play an important part in the structure of the rugged mass of mountains, which, commencing to the southwest of Charlottesville, and occupying the center of the valley, extend as far as Lynchburg. They are called near Charlottesville "The Ragged Mountains." Formed of a capping of quartzite, disturbed by the syenites, they assume the character of short ranges confusedly arranged. Toward Lynchburg they are less largely composed of stratified rocks. Various coarse granites and syenites make up most of their mass, especially in the short

ranges called "Tobacco Row" and "No Business Mountains," lying above Lynchburg on both sides of the James.

The predominant rock along the railroad is a mica slate, and schist of varying character, but is mainly slate with micaceous matter in excess. The dip is usually high to the southeast. This is, however, not rarely reversed by the influence of the syenites. Near the eastern foot of the Blue Ridge, a very coarse gneiss is found.

The railroad climbs the mountain to the height of about seven hundred feet, gradually passing inward over the east slope, so that the tunnel is cut through the center and crest of the range. The mountain proper in the vicinity of Rockfish Gap is composed of argillites, highly altered by local metamorphism. Some very interesting effects are to be seen in passing over the eastern slopes. The metamorphic agent seems to have acted more energetically in certain bands, making an acute angle with the general direction of the mountain. Along these bands the slates have lost their cleavage, and have become much impregnated with epidote, quartz and chlorite. These three minerals often form concretionary masses, four to five feet in diameter, in which they are confusedly mixed together. Such lines of increased metamorphic action are, I think, determined by crevices or breaks in the strata.

The Blue Ridge at this point is a single chain, composed of highly altered argillites, with a central mass of eruptive rocks. Commencing at the east entrance of the tunnel, which is seven-eighths of a mile long, we find the argillite in heavy beds, lying with a dip of about 50° to the southeast. These slates have a dark greenish-grey color, from the presence of films of chlorite. They continue in the tunnel for about eight hundred and fifty yards, when we come upon an eruptive igneous rock, which extends about one hundred yards. This is succeeded by argillites, which continue with the same southeast dip to the edge of the Silurian strata, which are found near the west entrance. The southeast dip continues into the Silurian beds, but its steepness increases.

A belt of argillite on each side of the eruptive rock occurs, highly altered by the influence of the latter. In these belts the slates lose their bedding and cleavage, resemble a compact mass of angular fragments, and become impregnated with various minerals. When not thus impregnated, the texture is crystalline, the color grey, and the rock becomes harder and denser. The altered belt on the west side is much wider than that on the east, being as much as one hundred and fifty yards. In these altered belts occur many interesting associations of minerals, which can be well studied in the great mass of material used in making the two approaches of the tunnel.

The eruptive rock is a species of syenite of moderately fine texture. It contains a ground mass of rather fine granular red feldspar, quartz, hornblende and magnetic iron. In this occur porphyritically larger crystalline grains of red feldspar and quartz. The slates sometimes form a peculiar rock, indicating a gradual passage from slate to syenite, owing to contact effects. These portions might sometimes be mistaken for conglomerates, since they present rounded nodules of red feldspar and quartz, which exactly resemble water-worn pebbles. They lie imbedded in slaty matter, but perfectly distinct from it. We thus see that the structure here is precisely the same with that at Harper's Ferry. The central mass, however, is true igneous syenite. In composition it resembles the coarse syenite occurring farther southwest, but it is much better crystallized.

Among the products of metamorphism to be seen in the altered slates we may mention the following: 1. Rocks so highly impregnated with epidote as to appear a mass of acicular crystals. 2. The formation of numerous concretions of the size of a buckshot, composed of a core of epidote, with an envelope of milk-white quartz. 3. Calc spar with the characteristic cleavage. 4. This is sometimes intimately associated with epidote and silky fibers of asbestos, the spar being colored green by finely-disseminated hornblendic matter. 5. Masses of carbonate of lime, having a fine saccharoid texture like alabaster, and much like enclosed and metamorphosed fragments of ordinary limestone. They are, however, impregnations. Interesting studies both of the association and paragenesis of metamorphic minerals may be obtained.

The contact of the Silurian with the argillite is beautifully exposed in the west entrance of the tunnel, and the great contrast of the two systems thus brought side by side is well shown.

[To be continued.]

ART. III.—*Projection of the Fraunhofer Lines of Diffraction and Prismatic Spectra on a Screen;* by Prof. JOHN C. DRAPER, College of the City of New York.

HAVING been engaged during the past year in making photographs of absorption spectra of organic bodies, in which a solar spectrum with Fraunhofer lines was formed by a diffraction grating, I have resorted to the following method of forming such solar spectra, a description of which may prove of interest to those who are experimenting in the same field.

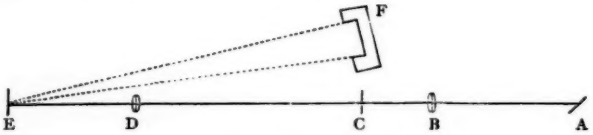
The grating generally used was made by Mr. L. M. Rutherfurd; it is ruled on speculum metal, 6,481 lines to the inch; it gives spectra by reflection. Other gratings on glass, now in my possession, give spectra by reflection and by transmission. The method answers equally well for both. It may be briefly stated as follows:

A beam of light is directed by the silvered plane mirror of a heliostat (A) into a darkened room.

It is received on an achromatic lens (B) ten centimeters in diameter; focal distance from posterior surface seventy centimeters.

A slit (C) is then placed within the focus of this lens, the distance being forty-eight centimeters from the lens (B).

After passing through the narrow slit, which is about one-tenth of a millimeter wide, the light is received upon a second achromatic lens (D), of the same diameter as the first, but with



a focal distance of one hundred and fifteen centimeters. The distance of this lens from the slit is one hundred and sixty-four centimeters, and the focussing of the lines of the spectrum on a paper screen or on the ground glass of the camera is accomplished by moving the lens (D) nearer to or farther from the slit (C), or by moving the camera or screen (F) itself.

The grating (E), mounted on a suitable stand, is placed at a distance of eighty centimeters from the second lens. All parts of the apparatus being carefully adjusted, so that A, B, C, D, E are on the same horizontal axis, the grating is then arranged on its vertical axis, to throw the center of its reflected image on the opening of the slit (C).

The lines of the grating being accurately parallel to the sides of the slit, a series of beautiful spectra are produced on each side of the slit, any or all of which may be received on suitably adjusted screens, one of which is represented at (F). In all of these spectra, if the slit has been very narrow, the prominent Fraunhofer, with numerous other lines, appear sharply defined.

Of the spectra described above, only the first, second and third orders on each side of the image of the slit are available for general use on account of the overlapping of those that follow. Of those that are available, I have preferred to use the second order, since in this the dispersion is much greater than

in the first, and by the apparatus described above a spectrum of a length of more than thirty centimeters is obtained.

For the projection of the prismatic spectrum a prism is substituted in place of the grating, when a very fine spectrum is produced, the focus of the violet end of which is very much closer to the prism than that of the red end.

In the diffraction spectra, also, it is necessary to vary the angle at which the screen is placed to define sharply the lines at the extremities of each spectrum. In the spectra of the first order on each side, the screen is placed very nearly at right angles to a line drawn from the grating to (*b*), in the spectrum. As each order in succession is examined, the divergence from this angle is greater and greater, and at the same time the focal distance of the lines moves nearer to the grating.

The lenses I have employed were those of a very fine photographic combination; they give with the rest of the arrangement a spectrum in which the definition of the lines is perfect, and they are present by hundreds. Though the lenses are ten centimeters in diameter, only the central portion of each is used, a diaphragm with a circular aperture of five centimeters or less being placed in front of (B).

To form the absorbent spectra of any organic substance, a suitable solution of the same is poured into a cell with parallel sides. This is placed at any convenient point between A and B, care being taken that the faces of the cell are at right angles to the course of the ray A, B. The slit may in this case be opened wider, when each spectrum will show the characteristic absorbent bands of the substance employed, the position being indicated (and if required, recorded) by their relation to the lines of the solar spectrum in which they are produced.

When the calcium or electric light is to be used for lecture room demonstration of diffraction spectra, the lens (B) should have as short a focus and as large a diameter as possible. The grating may also be so arranged on its vertical axis as to throw its image at a right angle to the line B, E, to be there received on a screen. Though by this device the spectra on one side of the image of the grating are greatly elongated and those on the other compressed, it presents the advantage of enabling the audience to see all the spectra at once, and also the optical contrivances by which they are produced.

November 25, 1874.

ART. IV.—*Abstract of results from a new discussion of the secular change of the Magnetic Declination in the United States, and some adjacent places in North and Central America;* by CHARLES A. SCHOTT, Assistant U. S. Coast Survey.

(Read before the National Academy of Sciences, Nov. 4, 1874.)

[Communicated by permission of CARLILE P. PATTERSON, Superintendent U. S. Coast Survey.]*

THE present investigation incorporates the additional observations made or collected since 1859, and contains the improved results for the old stations as well as those for a number of new stations. The circular function adopted in the previous discussion to represent the secular change, continued to lead to satisfactory results, as might have been expected from its great adaptation to represent curves of a periodic character. Independent of the study of terrestrial magnetism, the necessity for the occasional reconstruction of the numerical expressions is sufficiently apparent from the demands of the Survey and the use which is made of them for the magnetic data given on our charts, viz: the magnetic declination (variation of compass) for a certain epoch, or date of publication, and its rate of change.

To briefly recapitulate the formulæ employed, let

$$D=\delta+r \sin (\alpha m+c)+r_1 \sin (\alpha_1 m+c_1)+ \ . \ . \ .$$

express the magnetic declination at any time t, positive when west, negative when east of north; also, let m=number of years (and fraction of a year) from the adopted epoch t, or $m=t-1850$.

$\alpha \ \ \alpha_1 \ . \ .$ factors depending on the adopted periods,

$$p \ \ p_1 \ . \ . \text{ or } \alpha=\frac{360^\circ}{p} \quad \alpha_1=\frac{360^\circ}{p_1} \ . \ . \ . \ .$$

The quantities δ, a constant representing a mean declination, $r \ r_1 \ . \ . \ . \ .$ parameters, and $c \ c_1 \ . \ . \ . \ .$ epochal constants of the periodic terms, are to be determined from the observations at any one place by the application of the method of least squares, in order to satisfy the condition that the sum of the squares of the residuals of the observed and computed declinations shall be a minimum ($\Sigma\Delta^2$=a minimum). For this purpose put $\delta=\delta_1+x$, where δ_1=an assumed approximate value δ, and x a correction to it; also,

$$r \cos c=y \quad \text{and} \quad r \sin c=z,$$

then the conditional equations will take the form

$$0=\delta_1-D+x+\sin \alpha \, m \, . \, y+\cos \alpha \, m \, . \, z+ \ . \ . \ .$$

* The paper in full will be published in Coast Survey Report for 1874. It is an extension of the article which appeared in this Journal, vol. xxix, Art. XXIX, May, 1860.

which are to be treated in the usual manner. To determine the value of α α_1 three (or more, if necessary) assumptions are made, and those values which render $\Sigma\Delta^2$ a minimum are deduced, and finally adopted. In some cases, where certain observations were evidently less trustworthy than others, and which nevertheless could not be dispensed with on account of the small number of observations, or on account of their reference to desirable epochs, special weights were assigned; generally the observations received the weight unity, a few imperfect observations the weight one-half. Of observations evidently grossly in error, no notice was taken.

The second periodic term depending on r_1 α_1 c_1 could only be established for a few places, owing to insufficiency in the number of observations and their want of the greater accuracy demanded for it.

The annual change v in the magnetic declination, positive when increasing west (or decreasing east), also the epoch of minimum west declination (or of maximum east declination), also its amount and the apparent probable error of an observation, are found as follows:

Differentiating the expression for D, we have

$$d\,\mathrm{D}=r\alpha\cos(\alpha m+c)dm+r_1\alpha_1\cos(\alpha_1 m+c_1)dm+\ldots$$

hence for any time t, and for minutes of arc,

$$v=60\sin 1^{\circ}[r\alpha\cos(\alpha m+c)+r_1\alpha_1\cos(\alpha_1 m+c_1)+\ldots]$$

Maxima and minima are deduced from the equation

$$0=r\alpha\cos(\alpha m+c)+r_1\alpha_1\cos(\alpha_1 m+c_1)+\ldots$$

from which expression we can find m.

The apparent probable error e_0 of an observation is deduced from the differences Δ of the n observed and computed values by the formula

$$e_0=\sqrt{\frac{0{\cdot}455\Sigma\Delta^2}{n-n_1}}$$

where n_1 equals the number of unknown quantities in the expression of D, which had to be found from the observations; when weights, w, are used, substitute $w\Delta^2$ for Δ^2. The greater part of this apparent probable error is due to the fact that the observations collected at any one station were not generally made at the same spot; it represents, consequently, local irregularities in the distribution of magnetism, as well as pure observing errors.

The principal uncertainty in the investigation arises partly from the large observing errors in the older observations, made with ordinary compasses or with rude instruments generally, and partly, since the introduction of the refined instruments,

the theodolite and magnetometer, from the circumstance that the various observations for the same nominal locality were taken at different spots, involving changes of local deflections of the magnet. From the extended use of iron and the growth of cities, it is difficult to select and preserve in such places a suitable locality for use at future times. Accurate investigations of the secular change can only be made at permanent observatories, or in localities not liable to disturbing influences.

In applying a periodic function to the investigation of the secular change, it is *not implied* that the phenomenon is necessarily of a periodic character, or must exhibit more than a single *complete* period; the aim is to represent by such a function the changes in the direction of the magnetic resultant, as far as observed.

The collection of the material is given first, the stations being arranged in geographical order, beginning in the northeast, passing to the south and west, and ending in the northwest.* For each locality the observed declinations are given in chronological order, together with such notes and references, respecting observer, place, publication, etc., as could be found. The stations here given are the only ones at present suitable for a discussion of the secular change, but their number is constantly increasing by the accumulation of new facts. [The collection referred to is here omitted.]

The following table contains the empirical expressions for the magnetic declinations derived from the collected observations by the process explained above, for various localities, together with their latitudes and longitudes. Total number of stations, 43, and of observations, about 417.

TABLE I.

Locality.	Latitude	Longitude	Expression of Magnetic Declination.
Halifax, N. S.	44° 39·6′	63° 35·3′	$D = +15°\cdot94 + 4°\cdot42 \sin(1\cdot0\ m + 49°\cdot2)$
Quebec, Can.	46 48·4	71 14·5	$D = +12\cdot67 + 3\cdot84 \sin(1\cdot65m + 43\cdot6)$
York Factory, Hud. Bay.	57 00·	92 26·	$D = +5\cdot08 + 14\cdot12 \sin(1\cdot6\ m - 79\cdot4)$
Portland, Me.	43 38·8	70 16·6	$D = +10\cdot72 + 2\cdot68 \sin(1\cdot33m + 24\cdot1)$
Burlington, Vt.	44 28·2	73 12·3	$D = +11\cdot16 + 3\cdot76 \sin(1\cdot30m - 26\cdot3) + 0\cdot18 \sin(7\cdot2m + 138)$
Rutland, Vt.	43 36·5	72 55·5	$D = +9\cdot76 + 3\cdot64 \sin(1\cdot6\ m - 19\cdot6)$
Portsmouth, N. H.	43 04·8	70 43·0	$D = +10\cdot29 + 2\cdot56 \sin(1\cdot37m + 5\cdot9)$
Newburyport, Mass.	42 48·4	70 49·0	$D = +9\cdot63 + 2\cdot63 \sin(1\cdot4\ m + 13\cdot2)$
Salem, Mass.	42 31·9	70 52·5	$D = +10\cdot22 + 4\cdot04 \sin(1\cdot55m - 6\cdot1)$
Boston, Mass.	42 21·5	71 03·8	$D = +9.46 + 2\cdot83 \sin(1\cdot3\ m + 4\cdot6)$
Cambridge, Mass.	42 22·9	71 07·7	$D = +9\cdot58 + 2\cdot69 \sin(1\cdot3\ m + 7\cdot0) + 0\cdot18 \sin(3\cdot2m + 44)$

* This approximates to an arrangement proceeding from the greatest western to the greatest eastern declinations.

TABLE I—*continued.*

Locality.	Latitude	Longitude	Expression of Magnetic Declination.
Nantucket, Mass.	41° 17·0	70° 06·0	$D = +\ 8°.94 + 2°.45 \sin(1.35m + 13°.8)$
Providence, R. I.	41 49·5	71 24·1	$D = +\ 9.10 + 2.99 \sin(1.45m - 3.4) + 0.19 \sin(7.2m + 116)$
Hartford, Conn.	41 46·	72 40·8	$D = +\ 8.06 + 2.90 \sin(1.25m - 26.4)$
New Haven, Conn.	41 18·5	72 55·7	$D = +\ 7.83 + 3.16 \sin(1.4\ m - 21.6)$
Albany, N. Y.	42 39·2	73 45·8	$D = +\ 8.22 + 3.05 \sin(1.44m - 9.7)$
Oxford, N. Y.	42 26·5	75 40·5	$D = +\ 6.19 + 3.24 \sin(1.35m - 18.9)$
Buffalo, N. Y.	42 52·8	78 53·5	$D = +\ 3.40 + 3.41 \sin(1.4\ m - 23.3)$
Erie, Pa.	42 07·8	80 05·4	$D = +\ 1.27 + 2.00 \sin(1.4\ m - 10.5)$
Cleveland, O.	41 30·3	81 42·0	$D = -\ 0.34 + 1.89 \sin(1.4\ m + 6.0)$
Detroit, Mich.	42 20·0	83 03·0	$D = -\ 0.96 + 2.22 \sin(1.5\ m - 15.7)$
New York City.	40 42·7	74 00·4	$D = +\ 6.43 + 2.29 \sin(1.6\ m - 5.5) + 0.14 \sin(6.3m + 64)$
Hatboro, Pa.	40 12·	75 07·	$D = +\ 5.23 + 3.28 \sin(1.54m - 13.2) + 0.22 \sin(4.1m + 157)$
Philadelphia, Pa.	39 56·9	75 09·0	$D = +\ 5.42 + 3.35 \sin(1.55m - 22.9)$
Washington, D. C.	38 53·3	77 00·6	$D = +\ 1.79 + 1.90 \sin(1.5\ m + 5.9)$
Cape Henry, Va.	36 55·5	76 00·5	$D = +\ 2.95 + 2.95 \sin(1.55m - 35.3)$
Charleston, S. C.	32 46·6	79 55·8	$D = -\ 2.75 + 2.38 \sin(1.6\ m + 15.2)$
Savannah, Ga.	32 04·9	81 05·5	$D = -\ 2.54 + 2.32 \sin(1.5\ m - 28.6)$
Key West, Fla.	24 33·5	81 48·5	$D = -\ 4.75 + 2.54 \sin(1.4\ m - 16.4)$
Havana, Cuba.	23 08·	82 22·	$D = -\ 4.82 + 1.44 \sin(1.3\ m - 38.2)$
Kingston, Jamaica.	17 55·	76 50·	$D = -\ 4.69 + 1.95 \sin(1.2\ m + 16.0)$
New Orleans, La.	29 57·2	90 03·9	$D = -\ 5.68 + 2.52 \sin(1.4\ m - 63.8)$
Vera Cruz, Mex.	19 12·	96 09·	$D = -\ 3.77 + 5.89 \sin(1.1\ m - 60.5)$
Mexico, Mex.	19 25·9	99 06·0	$D = -\ 4.30 + 4.59 \sin(1.1\ m - 76.5)$
Acapulco, Mex.	16 50·5	99 52·3	$D = -\ 3.97 + 4.96 \sin(1.05m - 76.7)$
Panama, New Granada.	8 55·	79 30·	$D = -\ 6.28 + 1.57 \sin(1.2\ m - 13.9)$
San Blas, Mex.	21 32·6	105 15·7	$D = -\ 5.60 + 3.37 \sin(1.0\ m - 87.7)$
San Diego, Cal.	32 42·1	117 14·3	$D = -12.54 + 1.64 \sin(1.2\ m - 180.0)$
Monterey, Cal.	36 36·2	121 53·6	$D = -12.82 + 3.54 \sin(1.0\ m - 142.9)$
San Francisco, Cal.	37 47·5	122 27·2	$D = -13.50 + 3.10 \sin(1.0\ m - 132.7)$
C. Disappointment, W. T.	46 16·7	124 02·0	$D = -20.72 + 2.81 \sin(1.2\ m - 188.8)$
Sitka, Alaska.	57 02·9	135 20·	$D = -29.08 - 0.010m + 0.00098m^2$
Unalaska Island, Alaska.	53 52·6	166 31·5	$D = -20.05 + 0.024m + 0.00080m^2$

In the second table are exhibited, for each locality discussed, the observed and computed declinations (by preceding formulæ), expressed in degrees and fractions of a degree.

TABLE II.

Year.	Obsd.	Compd.	Year.	Obsd.	Compd.	Year.	Obsd.	Compd.
	Halifax. N. S.			Quebec, Can.			York Factory.	
1756·5	+12°·83	+12°·85	1649·5	+16°·0	+16°·34	1725·5	+19°·0	+19°·04
1775·5	13·58	14·05	1686·5	15·5	15·44	1787 5	+5·0	+4·93
1798·5	16·50	15·76	1810·5	11·0	11·25	1819·7	−6·00	−6·06
1818·0	17·47	17·25	1814·5	11·83	11·67	1843·5	−9·42	−9·05
1821·7	17·60	17·52	1831·5	13·62	13·54	1857·6	−7·62	−7·95
1852·5	18·17	19·41	1834·5	14·23	13·86			
1853·0	18·85	19·44	1842·5	14·20	14·66			
1860·5	19·92	19·76	1858·8	15·57	15·93			
1866·3	+21·09	+19·97	1859·5	16·28	15·97			
			1860·8	+16·47	+16·04			

TABLE II—*continued.*

Year.	Obsd.	Compd.
Portland, Me.		
1763·5	+7°·75	+8°·05
1775·5	8·50	8·14
1845·4	11·47	11·55
1851·6	11·69	11·91
1859·5	12·33	12·33
1863·5	12·47	12·52
1864·8	12·73	12·58
1865·5	12·71	12·61
1866·1	12·72	12·64
1873·7	+12·89	+12·94
Burlington, Vt.		
1793·5	+7·63	+7·63
1818·5	7·50	7·51
1822·5	7·70	7·69
1826·5	7·60	7·94
1830·5	8·17	8·21
1831·5	8·25	8·29
1832·5	8 42	8·37
1834·5	8·83	8·52
1837·5	8·75	8·75
1845·5	9·37	9·33
1855·7	9·95	9·94
1873·8	+11·32	+11·32
Rutland, Vt.		
1789·3	+7·05	+6·51
1810·4	6·07	6·14
1811·7	6·02	6·16
1859·6	9·82	9·49
1873·8	+10·67	+10·91
Portsmouth, N. H.		
1771·5	+7·77	+7·78
1775·5	7·75	7·74
1850·7	10·50	10·60
1859·5	+11·25	+11·12
Newburyport, Mass.		
1775·5	+6·75	+7·00
1781·5	7·30	7·02
1850·7	10·09	10·28
1859·5	+10·97	+10·81
Salem, Mass.		
1781·6	+6·90	+6·47
1805·8	5·95	6 32
1810·5	6·09	6·49
1849·6	10·24	9·75
1855·6	+10·83	+10·40
Boston, Mass.		
1700·5	+10°·00	+9°·95
1708·5	9·00	9·45
1741·5	7·50	7·52
1776·0	7·67	6·62
1782·5	7·00	6·64
1793·5	6·50	6 82
1807·5	6·08	7·28
1839·5	9·10	9·03
1846·7	9·52	9 49
1855·6	10·23	10·05
1872·7	+11·25	+11·01
Cambridge, Mass.		
1708·5	+9·0	+9·30
1742·5	8·0	7·70
1757·5	7·33	7·28
1761·5	7·23	7·17
1763·5	7·00	7·13
1780·5	7·03	6·90
1782·5	6·75	6·89
1783·5	6·87	6·90
1788·5	6·63	6·93
1810·5	7·50	7·52
1835·5	8·85	9·02
1837·5	9·15	9·15
1840·4	9·30	9·36
1842·2	9·57	9·49
1844·5	9·65	9 65
1845·4	9·53	9·72
1850·6	9·50	10·07
1852·5	10 13	10·20
1854·5	10·21	10·33
1855·4	10·91	10·39
1856·5	10·47	10·46
1859·2	10·80	10·63
1867·5	+10·70	+11·09
Nantucket, Mass.		
1775·5	+6·50	+6·50
1834·5	8·45	8·64
1838·9	9·04	8·89
1842·7	9·15	9·11
1843·7	9·17	9·17
1846·6	9·23	9 33
1855·6	9·97	9·83
1867·4	+10·33	+10·42
Providence, R. I.		
1717·5	+9°·60	+9°·73
1720·5	9·47	9·49
1725·5	9·23	9·14
1730·5	8·90	8·85
1735·5	8·65	8·59
1740·5	8·25	8·33
1745·5	7·98	8·02
1750·5	7·67	7·66
1755·5	7·35	7·27
1760·5	6·95	6·88
1765·5	6·72	6·53
1769·5	6 50	6·29
1775 5	6·33	6·15
1780·5	6·27	6·12
1785·5	6·22	6·17
1790·5	6·17	6·25
1795·5	6·17	6·32
1800·5	6·25	6·37
1805·5	6·32	6·40
1810·5	6·40	6·45
1815·5	6·50	6·55
1819·5	6·62	6·75
1825·5	6·85	7·06
1830·5	7·17	7·45
1835·5	7·57	7·90
1840·5	8·42	8·36
1841·5	8·52	8·45
1842·5	8·65	8 53
1843·5	8·77	8·60
1855·6	+9·52	+9·42
Hartford, Conn.		
1786·5	+5·42	+5·28
1810·5	4·77	5·25
1824·5	5·75	5·60
1829·0	6·05	5·76
1859·6	7·29	7·34
1867·6	+7·82	+7·84
New Haven, Conn.		
1761·5	+5·78	+6·04
1775·5	5·42	5·27
1780·5	5·25	5·07
1811·5	5·17	4·77
1819·8	4·42	5·00
1828·5	5·28	5·35
1835·3	5·68	5·71
1836·5	5·92	5·78
1837·9	5·83	5·87
1840·5	6 17	6·02
1845·7	6·29	6·37
1848·6	6·58	6·57
1855·6	7·05	7·08
1872·5	+8·46	+8·37

TABLE II—*continued.*

Year.	Obsd.	Compd.
Albany, N. Y.		
1817·8	+5°·73	+5°·71
1818·6	5·75	5·78
1825·3	6·00	6·07
1828·6	6·27	6·26
1830·5	6·30	6·37
1831·6	6·54	6·44
1834·8	6·67	6·64
1836·8	6·78	6·77
1847·9	7·58	7·57
1855·7	7·91	8·16
1856·7	8·58	8·23
1858·4	+8·28	+8·37
Oxford, N. Y.		
1794·0	+3·00	+2·96
1817·5	3·00	3·31
1828·5	4·50	3·79
1834·8	3·87	4·13
1836·8	4·15	4·26
1837·5	4·50	4·30
1838·5	4·45	4·36
1849·9	5·18	5·14
1857·3	5·73	5·68
1858·1	5·78	5·74
1859·0	5·83	5·81
1873·9	6·87	6·94
1874·4	+6·93	+6·97
Buffalo, N. Y.		
1797·5	0·00	+0·01
1837·5	+1·42	1·17
1839·5	1·25	1·30
1845·5	1·42	1·71
1859·5	2·94	2·81
1872·5	3·87	3·89
1873·5	+3·97	+3·97
Erie, Pa.		
1795·5	−0·72	−0·72
1841·6	+0·50	+0·51
1862·6	+1·55	+1·52
1873·4	+2·01	+2·03
Cleveland, O.		
1796·7	−2·00	−2·10
1830·5	−1·33	−1·03
1831·6	−1·25	−0·98
1834·1	−0·83	−0·87
1838·1	−0·58	−0·69
1841·3	−0·09	−0·54
1845·5	−0·65	−0·35
1859·5	+0·77	+0·29
1871·8	+0·54	+0 79
1872·5	+0·75	+0·81
1873·5	+0·85	+0·85

Year.	Obsd.	Compd.
Detroit, Mich.		
1810·5	−2°·80	−3°·10
1822·5	−3·22	−2·82
1828·5	−2·83	−2·61
1835·5	−2·17	−2·31
1840·5	−1·97	−2·07
1859·5	−0·70	−1·01
1865·5	−0·67	−0·66
1872·4	−0·42	−0·28
1873·4	−0·29	−0·22
New York City.		
1686·5	+8·75	+8·78
1691·5	8·75	8·68
1723·5	7·33	7·53
1750·5	6·37	5·85
1755·5	5·00	5·46
1789·5	4·33	4·30
1824·5	4·67	4·64
1834·5	4·83	5·17
1837 5	5·67	5·37
1840·6	5·45	5·61
1841·5	6·10	5·68
1844·6	6·22	5·92
1845·7	6·42	6·01
1846·3	5·56	6·05
1847·8	5 68	6·16
1855·6	6·72	6·73
1860 7	6·73	7·03
1873·8	+7·62	+7·63
Hatboro, Pa.		
1680·5	+8·47	+8·49
1690·5	8·25	8·30
1700·5	7 92	7·94
1710·5	7·47	7·49
1720·5	7·00	6·95
1730·5	6·42	6·30
1740·5	5·58	5·56
1750·5	4·92	4·67
1760 5	4·00	3·75
1770·5	2·92	2·89
1780·5	2·08	2·21
1790·5	1·83	1·84
1800·5	1·92	1·79
1810·5	2·00	2·07
1820·5	2·45	2·56
1830·5	3·00	3·20
1840·5	3·83	3·89
1850·5	+4·42	+4·60

Year.	Obsd.	Compd.
Philadelphia, Pa.		
1701·5	+8°·50	+8°·63
1710·5	8·50	8·30
1750·5	5·75	5·25
1793·5	1·50	2·27
1802·5	1·50	2·08
1804·5	2·08	2·07
1813·5	2·43	2·12
1837·5	3·87	3·16
1840·5	3 62	3·37
1841·7	3·90	3·46
1846·4	3·85	3·82
1855·7	4 53	4·60
1862·6	5·00	5·22
1872·8	+5·46	+6·14
Washington, D. C.		
1792·5	−0·24	−0·08
1809·9	+0·87	+0·25
1841·0	1·34	1·54
1842·0	1·40	1·59
1855·5	2 40	2·25
1856·6	2·36	2·30
1857·2	2·41	2·34
1860·7	2·44	2·50
1862·7	2·66	2·59
1863·6	2 70	2·63
1866·8	2·74	2·77
1867·5	2·80	2·80
1868·5	2·85	2·84
1869·3	2·88	2·87
1870·5	2·89	2·92
1871·5	2·95	2·96
1872·5	3·00	3·00
1873·5	3·00	3·04
1874·5	+3·10	+3·08
Cape Henry, Va.		
1732·5	+4·68	+4·74
1809·5	[0·00]	0·03
1832·5	+0·75	0·34
1856·7	+1·47	1·71
1865·8	[+2·54]	+2·40
Charleston, S. C.		
1742·5	[−5·38]	−3·69
1775·5	−3·80	−5·06
1784·1	−5·25	−5·13
1785·8	−5·75	−5·13
1825·0	−3·75	−3·75
1837·5	−2·90	−2·95
1841·4	−2·40	−2·69
1847·8	−2·25	−2·27
1849·3	−2·28	−2·17
1874·4	−0·97	−0·82

TABLE II—*continued.*

Year.	Obsd.	Compd.
Savannah, Ga.		
1817·5	−4°·00	−4°·68
1839·0	−4·30	−4·18
1852·3	−3 67	−3·52
1857·3	−3·46	−3·24
1874·2	−1·98	−2·23
Key West, Fla.		
1829·1	−6 42	−6·57
1843·5	−6·03	−5·84
1849·6	−5·48	−5·49
1860·7	−4·78	−4·81
1861·2	−4·75	−4·78
1862·7	−4·68	−4·69
1863·5	−4·60	−4·64
1864·5	−4·56	−4·58
1865·5	−4·52	−4·52
1866·2	−4·49	−4·47
Havana, Cuba.		
1726·5	−4·4	−4·37
1732·3	−4·5	−4·54
1815·5	−7·0	−6·25
1816·6	−5·5	−6·24
1857·1	−5·25	−5·52
1858·5	−5 75	−5·48
Kingston, Jamaica.		
1732·2	−6·0	−6·28
1791·8	−6·78	−6·26
1806·0	−6·5	−5·86
1820·5	−4·8	−5·34
1822·5	−4·9	−5·26
1832·5	−5·2	−4·86
1833·5	−4·7	−4·82
1837·8	−4·3	−4·56
1847·3	−3·67	−4·24
1857·2	−3·67	−3·88
1866·5	−4·95	−3·55
New Orleans, La.		
1720·5	−2 0	−3·39
1768·5	−7·83	−5·77
1796·5	−5·10	−7·34
1806·5	−8·05	−7·75
1840·5	−8·33	−8·14
1857·0	−8·00	−7·72
1858·3	−7·86	−7·67
1870·5	−7·10	−7·13
1872·1	−6·99	−7·05
Vera Cruz, Mex.		
1727·0	−2°·25	−2°·17
1769·4	−6·57	−6·79
1776·5	−7·5	−7·46
1815·5	−10·6	−9·0
1819·3	−9·3	−9·65
1856·6	−8·3	−8·49
1861·0	−8·3	−8·18
Mexico, Mex.		
1769·8	−5·45	−5·51
1804·0	−8·13	−7·94
1850·5	−8·59	−8·75
1856·9	−8·77	−8·58
1858·5	−8·37	−8·53
1860·5	−8·50	−8·46
1862·5	−8·34	−8·38
1867 0	−8·15	−8·18
1868·5	−8·17	−8·11
Acapulco, Mex.		
1744·5	−3·0	−3·32
1791·3	−7·73	−7·26
1822·5	−8·67	−8·74
1828·5	−9·12	−8·85
1838·0	−8·29	−8·91
1866·5	−8·37	−8·23
Panama, New Granada.		
1775·8	−7·8	−7·80
1790·8	−7·8	−7·83
1802·5	−8·0	−7·76
1822·5	−7·0	−7·42
1837·5	−7·03	−7·03
1849·5	−7·08	−7·67
1866·4	−5·93	−6·12
San Blas, Mex.		
1791·3	−7·47	−7·46
1822·0	−8·67	−8·64
1837·5	−8·57	−8·92
1839·5	−9·00	−8·94
1841·5	−9·20	−8·95
San Diego, Cal.		
1792·5	−11·00	−11·01
1839·5	−12·34	−12·18
1851·3	−12·48	−12·58
1853·8	−12·53	−12·67
1866·4	−13·16	−13·09
1872·9	−13·32	−13·29
Monterey, Cal.		
1791·7	−10°·93	−11°·48
1795·5	−12·37	−11·76
1837·5	−14·50	−14·29
1839·5	−14·22	−14·40
1841·5	−15·00	−14·51
1843·5	−14·00	−14·62
1851·1	−14·97	−15·01
1873·7	−15·92	−15·91
San Francisco, Cal.		
1792·9	−12·80	−12·97
1827·5	−15·45	−14·80
1829·5	−15·10	−14·90
1837·5	−15·17	−15·27
1839·5	−15·33	−15·35
1841·9	−15 50	−15·46
1850·0	−15·68	−15·78
1852·3	−15·48	−15·86
1866·5	−16·42	−16·28
1872·8	−16·43	−16·41
1873·6	−16·42	−16·43
1874·0	−16·47	−16·44
C. Disappointment, W. T.		
1792·3	−18·00	−17·98
1839·5	−19·18	−19·70
1842·5	−20·00	−19·86
1851·5	−20·54	−20·38
1873·8	−21·61	−21·67
Sitka, Alaska.		
1804·5	−26·75	−26·58
1824·5	−27·50	−28·18
1827·5	−28·83	−28·36
1829·5	−28·32	−28·46
1830·0	−28·27	−28 48
1838·5	−28·62	−28·83
1839·5	−29 53	−28·86
1842·5	−28·88	−28·95
1851·0	−29·23	−29·09
1867·6	−28·82	−28·95
Unalaska Island, Alaska.		
1792·5	−19·0	−18·79
1806·5	−19 4	−19·58
1829·0	−19·9	−20·20
1848·5	−19·51	−20·08
1849·5	−20·00	−20·06
1867·7	−19·79	−19·38
1870.5	−19·75	−19·22
1873·4	−19·00	−19·05

The third table shows the number of observations at each place; the apparent probable error of one observation (including errors arising from want of identity of stations and from instrumental defects) expressed in minutes of arc; the computed epochs of greatest easterly deflection in the secular motion, together with the amount and direction of the declination at that epoch, and the computed annual changes at the epochs 1870 and 1880, expressed in minutes.

TABLE III.

Locality.	Number of Observations.	Apparent probable error of an observation.	Epoch of *easterly* secular digression (needle stationary).	Amount when at easterly digression.	Annual change in 1870.	Annual change in 1880.
Halifax, N. S.	9	±33′	1711	+11°·5	+1′·6	+0′·9
Quebec, Canada.	10	15	1769	+8·8	+1·7	---
York Factory, Hudson Bay.	5	14	----	---	---	---
Portland, Me.	10	9	1764	+8·0	+2·4	+1·6
Burlington, Vt.	12	6	1810	+7·4	+5·7	+6·0
Rutland, Vt.	5	15	1807	+6·1	+5 9	+5·4
Portsmouth, N. H.	4	5	1780	+7·7	+3·1	+2·5
Newburyport, Mass.	4	13	1776	+7·0	+2·9	+2 2
Salem, Mass.	5	26	1796	+6·2	+5·9(?)	+5 0(?)
Boston, Mass.	11	25	1777	+6·6	+3 3	+2·8
Cambridge, Mass.	23	11	1783	+6·9	+2·9	+2·1
Nantucket, Mass.	8	6	1773	+6·5	+2·6	+2·3
Providence, R. I.	30(?)	7	1780	+6·1	+3·8	---
Hartford, Conn.	6	14	1799	+5·2	+3·4	+3·0
New Haven, Conn.	14	9	1801	+4·7	+4·6	+4·3
Albany, N. Y.	12	6	1794	+5·2	+4·3	+3·8
Oxford, N. Y.	13	9	1797	+3·0	+4·5	+4·3
Buffalo, N. Y.	7	8	1802	0·0	+4·9	+4·7
Erie, Pa.	4	--	1793	−0·7	+2·8	+2·5
Cleveland, O.	11	12	1781	−2·2	+2·3	+1·9
Detroit, Mich.	9	11	1801	−3·2	+3·4	+3·0
New York City.	18	15	1797	+4·0	+2·4	+2·5
Hatboro, Pa.	18(?)	6	1797	+1·8	+4·6	+4·5(?)
Philadelphia, Pa.	14	20	1807	+2·1	+4·7	+3·7
Washington, D. C.	19	6	1786	−0·1	+2·4	+1·9
Cape Henry, Va.	5	14	1815	0·0	+4·8(?)	+4·7(?)
Charleston, S. C.	9	19	1784	−5·1	+2·7	+1·8
Savannah, Ga.	5	15	1809	−4·9	+3·6	+3·5
Key West, Fla.	10	4	1797	−7·3	+3·6	+3·4
Havana, Cuba.	6	26	1810	−6·3	+1·9	---
Kingston, Jamaica.	11	25	----	−6·6	+1·9	---
New Orleans, La.	9	30	1831	−8·2	+3·0	+3·4
Vera Cruz, Mex.	7	17	1823	−9·7	+5·3	---
Mexico, Mex.	9	5	1838	−8·9	+3·1	+3·8
Acapulco, Mex.	6	21	1837	−8·9	+3·1	+3·8
Panama, New Granada.	7	13	1787	−7·9	+1·9	+1·8
San Blas, Mex.	5	10	1848	−9·0	+1·3	---
San Diego, Cal.	6	6	1925	−14·2	−1·9	−1·7
Monterey, Cal.	8	21	1903	−16·4	−2·0	−1·5
San Francisco, Cal.	12	9	1893	−16·6	−1·3	−0·7
Cape Disappointment, W. T.	5	12	1932	−23·5(?)	−3·4	−3·1
Sitka, Alaska.	10	18	1855	−29·1	+1·8	+2·9
Unalaska Island, Alaska.	8	17	1835	−20·2	+3·4	+4·4

The probable errors given above will serve to convey some rude idea of the relative value of *each series* of observations; the imperfections in the instrumental means of the older observations in many cases react unfavorably on the modern observations made with more precise instruments; the observations, for instance, taken by Hudson in 1609, in the vicinity of New York Bay, are fairly chargeable with a probable error of $\pm 3°$ (a single result); those tak n by Vancouver on our western coast, between 1792 and 1794, are subject to a probable uncertainty of $\pm 1°$ (each). Increased precision was obtained with the improvements of the azimuth compass and the allowance for disturbing effect of the ship's iron, and, for shore stations, with the introduction of the theodolite for determining the astronomical meridian. With a portable magnetometer (collimator) the *instrumental* means need not leave a greater uncertainty than about one minute, but the *actual probable error* of any determination is limited by the accidental variations in the mean directions of the magnetic force from day to day, making it desirable to continue the observations for three or more days and to correct them for daily variation. It is principally dependent on the magnitude of the horizontal force.

A cursory examination of the column containing the epochs of greatest *easterly* excursion, the *deflecting* force producing the secular change attaining then an easterly maximum, shows that the needle became stationary in direction and then reversed its secular motion in the New England States toward the end of the past century, in the Atlantic Coast States, to the west and south, early in the present, and in Mexico about the close of the first third of the present century. In California, Oregon and Washington Territory it has not yet reached this condition. We thus have the following epochs for comparison: Halifax about 1711; Portland, Portsmouth, Newburyport, Salem, Boston, Cambridge, Nantucket and Providence about 1799; Hartford, New Haven, New York, Hatboro, Philadelphia, Washington and Cape Henry about 1800; Charleston, Savannah, Key West and Havana about 1800; New Orleans about 1831; Vera Cruz, Mexico, Acapulco and San Blas about 1837; San Diego, Monterey and San Francisco, expected about 1907 (yet very uncertain). We are thus directed to the extreme northeastern States for probable indications of what may be expected to follow on the seaboard in more southern and western States. Respecting the secular movement of the needle, apparently a little more than a century passed before the influence which produced the turning of the north end of the needle westward in Maine (increasing there the western declination) was felt in Lower California (diminishing there the eastern declination); in California, Oregon and

Washington Territory the eastern declination is at present still increasing, but with a losing rate. By the time the western elongation of the secular change is reached in Maine we may expect to see the needle in the opposite phase, or at its eastern elongation, in California. We cannot as yet follow this influence directly over the interior of the United States for want of early observations; the westernmost interior stations for which an epoch could be made out were Buffalo, Erie, Cleveland and Detroit; these give the average turning epoch 1794. It may be quite practicable hereafter to trace out curves uniting all stations where the needle was stationary at a given epoch and again at other epochs for regular intervals of time, say of 10 or 25 years.

Returning to the first table, the constant in each formula would represent the normal direction of the needle, about which the secular change would be performed in an average cycle of about 270 years, and with extreme deflections on either side of it, equal to the co-efficient of the periodic term—all under the *supposition* that the law of the secular movement was truly expressed. It is no doubt much more complex, and besides, may fail at any time; yet as far as our present experience reaches, and within the interval when the first reliable observations were made to the present time, it is found trustworthy.

Table of Decennial values of the Magnetic Declination computed from preceding equations.

These tables have been constructed to facilitate the reduction of observed declinations from one epoch to another; they will be found specially useful, when old lines run by compass have to be retraced and for the construction of isogonic charts for a given epoch.

Blanks occurring in the table indicate either no or doubtful values for the corresponding times; values given to the nearest tenth of a degree are less reliable than those given to hundredths. A + sign indicates west, a − sign east declination.

TABLE IV.

Year (Jan. 1st).	Halifax, N.S.	Quebec, Can.	York Factory.	Portland, Me.	Burlington, Vt.	Rutland, Vt.	Portsmouth, N.H.	Newburyport, Mass.	Salem, Mass.	Boston, Mass.	Cambridge, Mass.	Nantucket, Mass.	Providence, R.I.	Hartford, Conn.	New Haven, Conn.	Albany, N.Y.	Oxford, N.Y.	Buffalo, N.Y.	Erie, Pa.	Cleveland, O.	Detroit, Mich.
1640	...	+15·9	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1650	...	16·4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1660	...	16·5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1670	...	16·4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1680	...	15·9	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1690	...	+15·2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1700	...	...	...	...	...	...	...	...	...	+10·0	+9·8	...	...	...	...	...	...	...	...	...	...
1710	...	...	...	...	...	...	...	...	...	9·3	9·2	...	+10·4	...	...	...	...	...	...	...	...
1720	...	...	+18·6	...	...	...	...	...	...	8·7	8·7	...	9·5	...	...	...	...	...	...	...	...
1730	...	...	19·2	...	...	...	...	...	...	8·1	8·3	...	8·9	...	...	...	...	...	...	...	...
1740	...	...	18 8	...	...	...	...	...	...	7·6	7·9	...	8·4	...	...	...	...	...	...	...	...
1750	+12 5	...	17·2	...	...	...	...	...	...	7·2	7·5	...	7·7	...	...	...	...	...	...	...	...
1760	13·0	...	14·8	+8·1	...	...	...	...	...	6·8	7·2	...	6·9	...	+6·1	...	...	...	...	...	...
1770	13 7	...	11·6	8·1	...	...	+7·8	+7·0	...	6·7	7·0	+6·5	6·3	...	5·5	...	...	...	...	...	...
1780	14·4	...	7·9	8·2	...	+7·0	7·7	7·0	+6·4	6·6	6·9	6·5	6·12	+5 4	5·1	...	...	...	...	...	...
1790	15·1	...	4·0	8·5	+7·7	6·5	7·8	7·2	6·2	6·7	6·9	6·7	6·24	5·2	4·8	...	+3·01	+ 14	−0·7	−2·2	...
1800	15·9	...	+0·1	8·9	7·52	6·2	8·0	7·4	6 2	7·0	7·1	7·0	6·37	5·16	4·7	...	2·96	−0·01	−0·7	−2·0	−3·18
1810	16·7	+11·2	−3·3	9·4	7·39	6·14	8·4	7·8	6·5	7·4	7·5	7·4	6·45	5·24	4·8	+5·4	3·10	+0·05	−0·6	−1·8	−3·11
1820	17·4	12·3	−6·1	10·0	7·58	6·39	8·8	8·4	7·0	7·9	8·0	7·84	6·73	5·46	5·0	5·79	3·40	0·30	−0·3	−1·5	−2·90
1830	18·1	13·4	−8·1	10·6	8·17	6·90	9·35	9·0	7·8	8·43	8·64	8·38	7·43	5·80	5·43	6·32	3·87	0·74	+0·03	−1·[illegible]	−2·55
1840	18·7	14·4	−9·0	11·23	8·94	7.64	9·94	9·6	8·7	9·05	9·33	8·95	8·31	6·24	5·99	6·97	4·46	1·33	0·44	−0·60	−2·09
1850	19·3	15·3	−8·8	11·82	9·62	8·53	10 55	10·23	9·8	9·69	10·03	9·53	9·09	6·77	6·67	7·70	5·14	2·05	0 91	−0·14	1·56
1860	19·8	16 0	−7·5	12·35	10·21	9·53	11·15	10·83	10·9	10·32	10·67	10·06	9·65	7·36	7·41	8·47	5·89	2·85	1·39	+0·31	−0·99
1870	20·1	+16·4	−5·3	12·80	10·97	10·54	11·7	11·4	11·9	10·90	11·21	10·54	10·21	7·99	8·18	9 2	6·65	3·68	1·87	+0·72	−0·41
1880	+20·3	...	...	+13·13	+11·97	+11·49	+12·2	+11·8	+12·8	+11·41	+11·63	+10·93	+10·94	+8·62	+8·9	+9·9	+7·38	+4·49	+2·31	+1·07	+0·13

TABLE IV—*continued.*

Year (Jan. 1st).	New York City.	Hatboro, Pa.	Philadelphia, Pa.	Washington, D. C.	Cape Henry, Va.	Charleston, S. C.	Savannah, Ga.	Key West, Fla.	Havana, Cuba.	Kingston, Jamaica.	New Orleans, La.	Vera Cruz, Mex.	Mexico, Mex.	Acapulco, Mex.	Panama, New Gran.	San Blas, Mex.	San Diego, Cal.	Monterey, Cal.	San Francisco, Cal.	Cape Disappointment, W. T.	Sitka, Alaska.	Unalaska Isl'd, Alas.
1640	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
1650	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
1660	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
1670	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
1680	+8·8	+8·5	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
1690	8·8	8·3	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
1700	8·5	7·9	+8·7	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
1710	8·0	7·5	8·3	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
1720	7·6	7·0	7·8	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
1730	7·2	6·3	7·0	---	+4·9	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
1740	6·6	5·6	6·2	---	+4·2	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
1750	5·9	4·7	5·3	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
1760	5·2	3·8	4·4	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
1770	4·6	2·9	3·6	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
1780	4·4	2·2	2·9	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
1790	4·29	1·8	2·4	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
1800	4·28	1·8	2·1	---	0·0	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
1810	4·30	2·03	2·1	+0·3	0·0	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
1820	4·47	2·53	2·28	0·6	0·0	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
1830	4·91	3·17	2·71	1·0	+0·25	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
1840	5·59	3·86	3·33	1·49	0·66	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
1850	6·34	4·57	4·11	1·99	1·24	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
1860	6·96	5·29	4·99	2·47	1·95	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
1870	7·43	6·0	5·89	2·90	2·73	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
1880	+7·84	+6·8	+6·76	+3·26	+3·5	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

ART. V.—*On the Tails of Comets;* by HENRY M. PARKHURST.

[Read before the Amer. Assoc. for the Adv. of Science, Aug. 18, 1874.]

IN predicting the form and position of a comet's tail, I adopt the theory of Professor Pierce:

"Each particle of the matter which composes the tail is supposed to move in a hyperbolic orbit, with the sun in the focus of the opposite branch, under the influence of a repulsive force emanating from the sun, and decreasing by the law of the inverse square of the distance." (Gould's Astronomical Journal, vol. v, page 186.)

The application of the formulæ gives for any required time one line only, commencing at the comet and extending indefinitely. Professor Pierce adopted, in his computations upon the tail of Donati's comet (Gould's Astr. J., vol. vi, page 51), an excess of repulsive force $1\frac{1}{2}$ times that of gravitation, making his comparisons with the front edge of the tail, and arbitrarily adopting such a repulsive force as best to explain the observations. For the purpose of comparing with the center of the tail, I adopted in my computations a repulsive force exactly equal to and replacing gravitation as the more probable law. On comparison with the observations, however, I find that the computed line closely agrees in nearly every instance with the observed right hand edge of the tail; and I shall, therefore, adopt that as the standard of comparison. Although the comet apparently moved in the other direction, yet in fact that was the front edge of the tail.

Most of the earlier observations were furnished to me by W. S. Gilman, Jr., of New York City, and all the later ones by Lewis Swift of Rochester, whose observations continued several days after the comet had ceased to be visible in New York City.

From June 12 to June 30, I have only the record of the direction of the tail, without reference to stars (G), agreeing with computation. On July 1, the tail "pointed to and reached 55 of Camelus." (P.) The computed line passes nearly through that star. On July 7, the front edge was seen a little to the left of 63 Arg. 749. (Bonn Catalogue.) (P.) The computed line passes a small fraction of a degree to the left of the star. On July 13, the last day when the head of the comet was favorably seen, "the right edge just touched *o* Ursa Major" as seen by Mr Swift, and passed $\frac{1}{2}°$ to the left of it according to my own record. The computed line passes $\frac{3}{4}°$ to the left of it The curvature on this evening was commonly noticed. Computation indicates an arc of about 15°. On July 14, "*h* U. Maj. was in the middle of the tail." (S.) Allowing for the recorded

width, it should be in the middle of the tail. On July 17, "v was exactly in the center," and "its left edge just touched α." (S). These are each within $\frac{1}{2}°$. On July 18, "it passed over α," (S.) and α U. Maj. was within the range of the computed tail. "θ and F (φ) were not only in the center of the tail but in line with its axis." (S.) They were within $\frac{1}{4}°$ of the computed center, and very nearly in the computed line of its axis at that point. On July 19, "the tail passed midway between α and β, but touched neither." (S.) The computed line passes nearly centrally between them. "Its left edge just touched δ." (S.) Here is an inaccuracy; for it could not have touched δ without passing over β. On July 20, it passed "midway between β and γ U. Maj., and centrally over δ." (S.) This agrees with computation. On July 21, the last day of its visibility, γ U. Maj. was seen "at its right edge, perhaps 1° within it." (S.) The computed line is 1° to the right of γ. "λ and μ U. Maj. were seen in the center of luminosity." (S.) This agrees exactly with computation. "No curvature perceptible." Computation indicates that the tail increased its curvature until about the 13th, a few days earlier the tail being too short for it to be perceptible, and a few days later the curvature itself becoming too small to be perceptible.

In all these cases the accordance of the right hand edge of the tail with the computed line was as close as the nature of the observation would admit. But among the observations kindly furnished me by Mr. Gilman, the accuracy and faithfulness of which I cannot doubt, are two which I cannot in fairness omit. On July 3, he recorded the place of the tail as wholly to the right of the two stars 65 Arg. 606, 607. The computed line passes to the left of those stars. As he did not use a diagonal prism, and inverted his chart in making the comparison, it seems impossible that he should have put it upon the wrong side, especially as his attention was also directed to the star 65 Arg. 599, near the other edge. On July 6, he recorded the place of the tail as passing through the star 63 Arg. 749, the chief star of an unmistakable group. The computed line passes nearly a degree further east. On this diagram you will see that the observed lines, before and after, are nearly parallel, and that these two widely deviate. You will also see, that in each case, connecting the observed point in the tail with the position of the head on the previous evening produces a line parallel to the rest; and although Mr. Gilman himself does not conceive it to be possible that he connected the position of the tail on one day with that of the head upon another, or that he could have even seen the comet on July 5, which was Sunday, I can find no other satisfactory solution of the discrepancy; and that explanation would substitute two observations accurately

agreeing with the computations, for two which are entirely inconsistent with the remainder of the series. Perhaps I should add that these observations, and indeed all the observations but one, were made without any expectation that they would ever be of value.

In predicting the width of a comet's tail, it may be assumed to bear a certain ratio to its length. Up to the time of the disappearance of the nucleus, the ratio of one-sixth was sufficiently exact. The tail was then approaching us, and on this account would be expected to appear to grow wider as well as longer. Assuming that it remained unchanged in form, it should have been about six times as wide on July 21 as on July 13. But instead of being 18° wide, it was seen to be only "$4\frac{1}{2}$°, possibly 5°."

I have refrained from alluding to an important point with regard to the front edge. When the tail is coming directly toward us, the front edge becomes the medial line. When the tail is 4° wide, assuming the right hand edge to be the front edge would involve an error of 2°; or, if the tail were 18° wide, as computed, it would involve an error of 9°. There is no such error; therefore, there is no visible portion of the tail to the right hand of the true front edge. If the tail is flat, lying in the plane of its orbit, we may readily understand why it should be so foreshortened when directed toward us. Indeed, this proves too much; for if it were as thin as Saturn's ring, it should have appeared as a mere line instead of being 5° wide. If the form of the section were elliptical, it would account for the observed width on the 21st of July; but when the tail was first seen, the earth was fully 11° above its plane, as seen from the comet, and the tail would have appeared much narrower in all the observations before July 13. The dark line behind the nucleus cannot indicate a hollow conical tail, for a diminution of the central light by $\frac{1}{24}$th part would hardly be perceptible; but that dark line, and the dark lines separating the different envelopes, are perfectly consistent with the theory of a thin flat tail.

There is another important fact. The front edge was toward the right until July 20; but at noon of July 21 the earth passed through the plane of the orbit. On the evening of July 21, therefore, when the tail was 5° wide, the front edge should have been either at the left hand, or at any rate at least 2° from the right hand edge; and yet the latter agreed with the line computed from the same formulæ with those of all the preceding days; and although the tail was seen for five days in succession, during which the earth passed through the plane of the orbit, there is no apparent discrepancy between the computed line and the observed position of the *right hand* edge of the tail.

A diagram I have constructed illustrates several results necessarily depending upon the hyperbolic theory. The black line represents the orbit of the comet of 1843, so far as included within the radius of the earth's orbit. The red lines, starting from the orbit, and after passing their perihelion points radiating in nearly straight lines from the sun, represent the hyperbolic orbits of particles of matter, leaving the head of the comet at the given times.

In these computations, also, I have adopted 1 as the ratio of repulsion. Had Coggia's comet possessed sufficient luminosity to be visible on July 24, it would have afforded a test of the true amount of repulsive force; but as its plane was still turned almost directly toward us when the tail was last seen, a variation in the assumed amount of the repulsive force makes no appreciable difference in its position; and the streamers seen extending from the convex side of the tail of Donati's comet suggest the theory that upon every formation of a new envelope, a small portion of the matter was endowed with a repulsion at least ten times that of the rest of the matter forming the tail.

The blue lines circling around the sun connect the positions of the particles in their hyperbolic orbits at given times, and therefore represent the visible and the invisible tail of the comet. The particles leaving the head of the comet thirty days before it reaches its perihelion, follow nearly behind it, with continually retarded motion, and when the head of the comet reaches the sun, those particles have only passed over half that distance, and are just about to commence their outward course. In receding from the sun the motion is gradually accelerated until the particles reach the same distance from the sun at which they left the head. The moment they pass outside of that point they are irrevocably lost. A reconversion of the repulsive force into attraction would not avail, but they must fly, unless intercepted, beyond the confines of our solar system.

Particles leaving the head of the comet at a later date pursue a somewhat similar course, coming nearer to the sun, but all at about the same time turning and flying off into space. The nearer they come to the sun before commencing their hyperbolic course, the more violent is the repulsion, and the greater their outward velocity. The particles which leave the head of the comet exactly at the perihelion, pursue a line almost directly from the sun, but about 66° from the axis of the comet's orbit. These particles commence their outward course with a velocity sufficient to carry them outside the earth's orbit in a little over two days; and that velocity remains nearly uniform in consequence of the sudden removal of the matter beyond the sphere of the sun's forcible action. Consequently,

when we undertake, for the 30th day after the perihelion passage, to trace the entire tail which has left the head during the preceding 60 days, we must pursue a curve commencing at the position of the head of the comet, passing to the right and downward, crossing the perihelion line at a distance from the sun one-third greater than that of the planet Neptune, and re-entering the earth's orbit above.

How much of this will be visible? As we follow the tail from the head it becomes fainter, first, because it is more distant from the sun, and therefore less illuminated. Another reason is that it is more diffused from its rapid expansion like the fire from a catharine wheel, the portion of the tail forming a certain arc, continually forming nearly the same arc of a larger circle. But is that all? Here is a portion of the tail above, more illuminated than the head of the comet itself, and which occupies less than one-fourth the space traveled over by the comet while it was issuing.

While the dark line in the center of a comet's tail seems to disprove the theory naturally suggested by the fact of the front edge being the line of computation, that the resistance of the ether is the cause of the expansion of the tail, the ether may have a perceptible effect upon its form and position. Had the sun an ether of its own, carried with it through that still more rare ether which brings to us the pulsations of light, the effect of the ether upon the tail would be only that resulting from the motion of the comet itself; but leaving the ether behind it in its course toward the constellation Hercules, it will tend to sweep the tail back from that point: and here we may find a possible explanation of the apparent wafting of the tail out of the plane of its orbit, leaving the front edge still on the right, and causing a thin, flat tail to have a visible width tenfold greater than it would have had if strictly in the plane of the orbit.

Note.—Observations in England on July 9, 14, 17, 18, 19 and 21, confirm the positions above given, but are not sufficiently definite for exact comparison. The theory of Prof. Norton (Am. Jour. Sci., 1861), that the width of the tail arises from the variation of the repulsive force exercised upon different particles of the cometary matter, and its thickness from the repulsion of the nucleus itself at the time of emission, I had not seen when the above was written. I have computed a new line consisting of particles equally repelled and attracted, and I find that it nearly corresponds with the former computed line, or with the observed right hand edge of the tail, apparently indicating that the tail was, from some cause, chiefly south of the plane of the orbit. The theory of Prof. Norton affords a plausible explanation of that cause.

New York, Oct., 1874.

ART. VI.—*The very much extended Nebulæ of Sir John Herschel's General Catalogue;* by CLEVELAND ABBE.

[Read before the Philosophical Society of Washington, June 4, 1874.]

In 1865 and 1867, I considered carefully the question of the apparent distribution of the nebulæ in space, basing my studies upon the General Catalogue of Sir John Herschel. Among other points that occupied my attention, I attempted, by separating the several general classes of nebulæ and clusters, to render more definite our ideas as to the different laws that obtain in reference to the distribution of resolvable and unresolved nebulæ.

Some of the conclusions then arrived at were published in the Monthly Notices of the Royal Astronomical Society for 1867, and have been in part confirmed by the subsequent writings of others. Mr. Proctor has rendered good service to this branch of Astronomy by reproducing on equal surface charts the table given by me showing the distribution of the unresolved nebulæ; which charts, published first in the Monthly Notices, and republished in his "Essays on Astronomy" and his "Universe," as well as the more elaborate and beautiful charts of Messrs. Waters and Proctor, are well adapted to convey such information as can be gained from this study. But whether we gauge the stars or the nebulæ, at best we can only obtain results that are exceedingly unsatisfactory, and perhaps no two persons would agree in adopting the same conclusions on this subject. In hopes of adding something more exact to our knowledge of the construction of the universe, I sought, two years ago, to resolve several more definite problems, such as involve fewer assumptions, and one of which I will now present, premising that the subject is brought to your notice, not because I think myself to have obtained anything conclusive, but because the problem seems to direct attention to a point worthy of special observation. In fact, the material I have had to work with has been so unsatisfactory that it will be a sufficient reward if I am able to so attract the attention of those possessing powerful telescopes as to induce them to revise the rough measurements that I have been obliged to content myself with.

The general problem, as it has presented itself to me, may be thus stated: We have thus far studied the distribution in space of the centers of the nebulæ,—are there not planes that have a definite relation to these bodies? Among the stars we have the Milky Way and the orbits of binary stars: among the planets we have their orbits and equators, and the orbits of their satellites; among the nebulæ we may expect to find analogous planes, whose relations to each other and to those already known cannot but be highly instructive. As yet we have but

very few double nebulæ, nor can we for a long time hope to determine the planes of the orbits of any binary nebulæ, if such exist; on the other hand, in regard to the axes of rotation of nebulæ or the planes of their equators, there is more room for study. It is a plausible hypothesis that some nebulæ are in rotation about their respective axes, and only in the case of an irregular nebula do we find presumptive evidence of numerous centers of aggregation and rotation; this latter class will not now further claim our attention. Those nebulæ whose whole mass is rotating about a single axis must appear to us either circular or elliptical, according to our position in relation to that axis; we might then at once assume that every well defined circular nebula has its axis of rotation directed toward us, and might thus determine the position of the plane of its equator; this, however, would be hazardous, since not only do we thus assume the fact of a rotation, but also assume that the average rotation of all nebulæ is so rapid that when viewed from any other direction they would present a sensibly elliptical outline; moreover, often globular clusters of stars are recorded as circular or globular nebulæ. I have therefore, for the present, passed by the circular and the ordinary elliptical nebulæ, and have confined myself to those described in Herschel's Catalogue as exceedingly or very much extended; the list of these, amounting in all to fifty-nine, is given in the accompanying table. In regard to them it may be remarked that if these nebulæ are gaseous and without rotation, we can only explain their apparent shape by supposing them to be endowed with a motion of translation, to be in fact wisps, like comet's tails; if, on the other hand, they be in a state of rotation, they must be flat rings or discs or extended flattened ellipsoids, and we are authorized to consider that the planes of their equators do sensibly pass through the position of the observer; similarly, if the nebulous appearance be due to the presence of lenticular or ring-shaped cloud of asteroids, or of meteoric dust, we shall be able to make a determination of the plane of the orbits of these bodies.

The trigonometrical formulæ by which we may compute the right ascension and declination of the poles of a very much extended nebula are given in the following note.

It is evident that the principal elements of uncertainty are, first, the inaccuracy of the adopted angles of position (π), and second, the error of the assumption that the planes of the nebulæ in question are not inclined to the line of sight. The latter error may, on the average, amount to 5° or 10°: the errors of the π may be averaged as about 5°, 15°, or 30°, according as the values are given in Herschel's Catalogue as exact, approximate or rough: the influence of these errors on our results can be easily ascertained by means of the differential formulæ.

Having computed the right ascensions and declinations of the south poles of the fifty-nine nebulæ in question, as given in columns six and seven of the accompanying table, I have also plotted them upon equal surface charts similar to those used by Messrs. Proctor and Waters, on which also have been drawn the limits of the Milky Way as given by those same gentlemen, according to Heis and Herschel. Owing to the fact that the unresolved nebulæ are, as a rule, far more numerous near the poles of the Milky Way than elsewhere, it follows at once that the greater number of the nebulæ now under consideration are near these poles, and therefore our poles of rotation, if we may presume to use that term, lie near the Milky Way itself: but a careful enumeration shows us that in the northern hemisphere these poles lie to the southward of the central portion of the Milky Way, while in the southern hemisphere the reverse holds good; in fact, there exists a medial plane about which the poles of these nebulæ cluster, and which is itself inclined to the plane of the Milky Way at an angle of about 30°, so that if the north pole of the Milky Way be in right ascension 12 h. 45 m. and declination 30°, the pole of the plane near which the rotation axes of the nebulæ lie will have about the same right ascension, but a declination of about 60°. Numerically expressed, this latter plane is so situated that of fifty nine nebulæ twenty-nine have their axes inclined to it by less than 10°, and forty-two have their axes inclined by less than 20°.

It is, I conceive, quite desirable that we should, on the one hand, have more accurate determinations of the position angles of these extended and ray-like nebulæ, and that, on the other hand, the reversion spectroscope of Zöllner should be applied to determine whether or no they be really in a state of rotation.

By adopting some average value for the oblateness of the spheroids, that appear to us as elliptical or oval nebulæ, it will be possible to obtain a certain approximate estimate of the probability that the plane here determined has some bearing upon the general question of the arrangement of the three or four thousand known nebulæ (the clusters being included); but such a computation involves too much of hypothesis to be of interest at present.

It may then in general be stated, that so far as we are able to determine the positions of planes of rotation among the nebulæ, they do not show any such tendency to agree with each other as is shown in the orbits and equators of the major planets of the solar system; that, on the contrary, they are inclined at all possible angles to each other, but have this remarkable feature, that their mutual nodes cluster about a point in right ascension 12 h. 45 m. and north declination 60°.

The Positions of the Poles of the "very much" and "exceedingly" "extended nebulæ" of Sir John Herschel's "General Catalogue," referred to the mean Equinox of 1860.

The Nebula.				Description.		Its South Pole.	
No.	R. A. h. m.	N. P. D. ° ′	π			R. A. h. m.	N.P.D. °
67	0 23·5	124 1·8	47·5	vB: L; vmE; psbM; f of 2	2†	8 29	127·7
132	0 40·1	111 30·9	172	F: vL; vmE.	2*	18 28	97·3
138	0 40·6	116 3·7	54·5	!!; vvB; vvL; vmE; gbM.	9*†	8 46	136·9
191	0 57·4	156 21·5	145·4	eF: vmE; vlbM.	1	16 48	103·2
361	1 27·8	120 7·6	118·3	vB; vL; vmE; sbM.	5	16 35	139·7
400	1 41·6	84 47·2	165±	vF; vmE; sbM.	3†	19 47	104·9
527	2 13·8	48 16·8	22·3	!; B; vL; vmE.	5†	7 12	106·4
610	2 40·3	120 51·5	151·1	vB; L; vmE; vbMN.	3	19 37	114·5
662	3 5·9	143 52·3	80	B; L; vmE; vgbM.	2	14 16	125·5
776	3 39·1	135 5·3	{221·6}{=41·6}	pB; L, vmE.	1	11 47	117·9
779	3 39·9	135 5·4	42·3	pF; pL; eE; vgpmbM.	3	11 52	118·3
811	4 0·6	144 29.4	10	B; L, vmE; bM.	2	10 33	95·8
823	4 6·6	123 14·1	32·2	B; vL; vmE; psmbM.	3†	11 22	116·4
1035	5 4·9	149 54·2	162	vF; pL; vmE.	2	22 2	98·9
1437	6 31·5	81 8·3	{330}{=150}	B; vmE; Ncom=*11.	7†	0 51	119·6
1472	6 49·4	130 41·5	44·8	pB; pL; vmE, pslbM.	2	15 1	122·3
1674	8 27·2	112 29·8	110·3	cB; L; vmE;	5	23 23	150
1713	8 44	56 3·6	40·9	vB; vL; vmE; gmbM.	5	13 1	122·9
1745	8 55·5	135 20·9	19	!; eeF; vL; vvmE.	1†	15 50	103·3
1823	9 12·3	38 25·6	150·8	vB; L; vmE; vsmbM=*10.	3	4 46	107·7
1931	9 40·3	55 56·2	90	!; cB; L; vimE.	3†	9 40	145·9
1958	9 46·4	87 56	111·5	vF; vL; vmE.	3	4 7	158·5
2003	9 56·7	115 29·4	82·3	cF; vL; vmE; lbM.	2†	20 46	153·5
2008	9 58·2	97 2·5	45	vB; L; vmE; vg, vsmbMEN	3	16 26	134·6
2238	10 44·6	52 38·5	42·5	pB; pL; vmE; * inv?	3*	14 48	122·5
2318	11 3	33 34·7	79	cB;vL; vmE; pbM; r.	3	11 55	122·9
2378	11 12·9	75 38·5	102	pB; vL; vmE.	8†	8 31	161
2413	11 18·4	45 38·5	0±	vB; cL; vmE; vsmbMN.	4	{17 or 5}18	90
2595	11 45·3	116 7·4	59·3	vF; cL; vmE.	1	20 11	140·4
2715	11 59	39 38·8	166·5	pB; vL; vmE; vgvlbM.	3	6 41	98·6
2749	12 2·9	42 46·3	109	pF; cL; vmE; vgbM.	3	10 23	130·0
2761	12 4	38 43·9	60±	pF; cL; vmE.	4	14 30	122·8
2786	12 6·7	74 19	152·1	B; vL; vmE; vsvmbM.	7	6 39	116·8
2806	12 8·8	76 4	17±	vB; vL; vmE; sbMN.	5†	17 52	106·5
2831	12 10·5	51 24·7	43·2	pB; vL; eE; vgbM.	3	16 8	122·4
2877	12 14·6	74 36·9	0±	L; vmE; f of 2.	4	{18 or 6}14	90
3066	12 26	89 8·9	95±	cB; vL; vmE; B* in cont.	3	7 4	175
3132	12 32·7	100 50·2	92	!; vB; vL; eE; vsmbMN.	3†	1 15	169·2
3142	12 33·7	27 36·8	118·6	B; L; vmE; glbM.	2	10 27	114
3189	12 37·1	57 3·8	34.3	!; pB; L; vmE; sp of 2.	6*†	17 15	118·2
3240	12 42·6	74 4·3	28.5	cB; pL; vmE; sbMN.	4†	18 8	117·3

The Nebula.				Description.		Its South Pole.	
No.	R. A. h. m.	N. P. D. ° ′	π			R. A. h. m.	N P.D. °
3278	12 45·9	78 0·6	34	pB; vmE; 3 B st s; f of 2.	6†	18 14	123·2
3321	12 49·9	67 33·3	120±	!; vB; vL; vmE; bMBRN=:?	10†	9 3	143·3
3340	12 52·4	54 23	30±	vF, pL; vmE; bet 2 st.	5†	17 38	114
3386	12 57·2	138 32·1	38.7	B; vL; vmE.	1	21 1	114·5
3437	13 4·5	52 11·2	25	vB, vL; vmE; vsbMN.	4	18 0	109·5
3525	13 17·3	132 17·2	122·5	!!; vB; vL; vmE; bifid.	4†	4 11	128·6
3696	13 47·9	83 58·5	15	F; pL; vmE; r.	7	19 40	104·9
3761	13 57·5	40 9·3	90±	pB; cL; vmE; smbMN.	2	13 57	130·2
3822	14 9·7	53 7·6	110·3	cF; pL; vmE; vgvmbM.	2	11 58	138·5
4004	14 47	85 53·1	148·4	F; pS; vmE; gvlbM.	4	8 57	121·5
4086	15 12·–	32 10·–	155	A ray; vmE, par. to 4087.	0	10 38	103
4087	15 12·2	33 10·1	155	cB; vL; vmE; vg, psbMN.	3†	10 38	103·4
4614	20 49·5	146 6·4	0	eeF; vS; vmE; *13 att, n.	2	{2 or 14} {49}	90
4663	21 19·2	143 23·3	90·8	eF; pL; vmE.	1	9 23	126·7
4679	21 26·6	145 10·8	127·1	pB; pL; vmE: g, pslbM.	1	12 19	117·1
4830	22 36·5	120 47·1	0	F; pL; vmE; vgvlbM.	1	{4 or 16} {36}	90
4860	22 47	130 24·6	43·3	cB; L: vmE; mbM.	2	6 53	121·5
4885	22 54·9	131 34·9	5±	cF: ps; vmE.	2	5 7	89·3

Columns 1–6 are copied from Herschel's General Catalogue. The position angles in column four have been micrometically measured when given to the tenth of a degree; have been carefully estimated when given with an appended ±; have been roughly estimated when given to the nearest 10°.

NOTE.—A nebula which seems a mere ray or line being situated at S′, prolong this ray into a great circle, S′S″, whose south pole is p, and join S′ and p with the north pole of the heavens, P. We now have,

$$\cos(d) = -\sin(\delta)\sin\pi$$
$$\tan(a-\alpha) = +\sec(\delta)\cot g\,\pi$$

where the sign of sin (d) is positive,
" cos ($a-\alpha$) is the same as the sign of cos (δ).
" sin ($a-\alpha$) " " " cos π.

π=PS′S″ or the positive angle of the ray measured *n. f. s. p.*
(δ)=PS′.
a=right ascension of south pole of nebula.
(d)=north polar distance of "

For a list of explanations of the meanings of the abbreviations used in the 5th and 6th columns of the accompanying tables, see pp. 11–13 of the original memoir by Herschel, in the Philosophical Transactions for 1874.

Washington, August 1st, 1874.

ART. VII.—*On Venus as a Luminous Ring;* by Prof. C. S. LYMAN.

IN this Journal,* eight years ago, a brief notice was published of some observations made by the writer on Venus when near her inferior conjunction in 1866. The planet was then (for the first time, so far as appears) seen as a very delicate luminous ring. The cusps of the crescent, as the planet approached the sun, had extended gradually beyond a semicircle, until they at length coalesced, and formed a perfect ring of light.

No opportunity has since occurred of repeating these observations until the day of the recent transit. On Tuesday, Dec. 8th, Venus was again in close proximity to the sun, and the writer had the satisfaction of watching the delicate, silvery ring enclosing her disc, even when the planet was only the sun's semi-diameter from his limb. This was at 4 P. M., or less than five hours before the beginning of the transit. The ring was brightest on the side toward the sun—the crescent proper. On the opposite side the thread of light was duller and of a slightly yellowish tinge. On the northern limb of the planet, some 60 or 80 degrees from the point opposite the sun, the ring for a small space was fainter, and apparently narrower, than elsewhere. A similar appearance, but more marked, was observed on the same limb, in 1866.

These observations were made with a five-foot Clark telescope of $4\frac{3}{5}$ inches aperture, by so placing the instrument as to have the sun cut off by a distant building while the planet was still visible. The ring was distinctly seen when the aperture was reduced to one and a half inches. The 9-inch equatorial could not be used, as there were no means of excluding the direct sunlight.

The morning after the transit the sky was slightly hazy and the planet could not be found, though probably it might have been if the small telescope had been mounted equatorially.

On the day following (the 10th), the crescent, extending to more than three-fourths of a circle, was seen with beautiful distinctness in the equatorial, and on this and two subsequent days, measurements were taken with the filar micrometer for the purpose of determining the extent of the cusps, and consequently the horizontal refraction of the atmosphere of the planet, on the assumption that the extension of the crescent and formation of the ring are due to this refraction.

The results of these observations are given below, each result being the mean of the number of separate measurements indicated in the last column. On the 10th, the chord of the arc between the cusps was measured; on the other days the

* Vol. xliii, p. 129.

distance between lines tangent to the cusps and to the opposite limb.

Mean dates. Dec.				Dist. of centers of ⊙ and ♀.		Extent of Crescent.		Hor. refr. of ♀'s atmos.	Num. of ob. of cusps.
8	3h	0m	P. M.	0°	36′·6	360°	00′		
10	11	36	A. M.	2	31·7	279	28	46′·6	4
11	10	16	A. M.	4	2·5	233	15	43·0	6
11	2	40	P. M.	4	20·4	231	46	45·5	15
12	2	45	P. M.	5	58·3	215	21	42·9	22
							Mean	44·5	

These observations give a mean of 44′·5 as the horizontal refraction of Venus's atmosphere, or about one-quarter greater than that of the earth's. The writer's observations, in 1866, gave 45′·3. Mädler, from observations of the cusps in 1849, when the nearest approach of the planet to the sun was 3° 26′, made the refraction 43′·7.

The formula for the refraction is this:

$$\sin y = \sin d \sin \frac{c - 180}{2}. \qquad 2x = y - \frac{r}{\rho}.$$

in which d = distance of centers of ○ and ♀.
c = arc of crescent.
r = sun's semi-diameter.
ρ = radius vector of Venus.
x = horizontal refraction of Venus's atmosphere.

Six measurements of the diameter of the planet on the 10th give 63″·1. Twenty-four, on the 11th, give 63″·75. The English and American Almanacs give 62″·4 and 64″·5 respectively.

ART. VIII.—*Discovery of a New Planet;* by Professor JAMES C. WATSON. From a letter to one of the editors, dated Peking, China, October 17, 1874.

I have the pleasure to send you the following places of a new planet which I discovered at 8h 30m on the evening of Oct. 10th.

Peking M. T.				α			δ		
1874, Oct. 10,	13h	30m	0s	0h	58m	1·68s	+10°	42′	52·0″
" 11,	9	58	15	0	57	15·48	10	40	33·9
" 11,	10	43	44	0	57	13·70	10	40	22·7
" 11,	11	31	0	0	57	11·75	10	40	24·8
" 13,	8	33	39	0	55	29·90	10	34	56·9
" 13,	9	43	44	0	55	27·67	10	34	38·5
" 13,	9	56	45	0	55	27·22	10	33	47·8
" 14,	9	35	11	0	54	33·71	10	31	57·3
" 15,	7	49	29	0	53	43·70	10	29	10·6
" 16,	8	58	34	0	52	46·46	10	26	15·0

The planet resembles a star of bright 11th magnitude.

Art. IX.—*Ancient Lake basins of the Rocky Mountain Region;* by Prof. O. C. Marsh.

The existence of several large fresh water lakes in the Rocky Mountain region, during Tertiary time, is now well established, mainly through the researches of explorers whom the striking scenery of the "Bad Lands," or the extinct animals entombed in them, have attracted thither. The geological age of some of these lakes, however, seems to be still in doubt, at least widely different opinions on this point are freely expressed. The extent of these various lake-basins, and their relations to each other, are likewise a subject on which information is especially desirable, and hence the results of some recent observations are here presented.

The deposits left in these old lakes show them to be of Eocene, Miocene, or Pliocene age, the fauna of each formation being entirely distinct, as well as quite different from existing species.

I. *Eocene Lake-basins.*

The oldest of the great Tertiary lake basins of the West are of Eocene age. The one first discovered and best known, which has been called the Green River basin, lies between the Rocky Mountains and the Wasatch range, in the depression now drained by the Green River. It has the Uintah Mountains for its southern border, and extends north at least as far as the Wind River range. This basin was visited by the writer in 1868, but first explored in 1870, when he traced its deposits for several hundred miles, and from the rich vertebrate fauna fully determined its Eocene age.* These same beds have since been pronounced Miocene by Prof. Hayden and others, but the 150 species of extinct vertebrates now known from them prove them Eocene as conclusively as any single formation has yet been determined in this country. A comparison of almost any group of these fossils with the corresponding one from the Paris basin will afford sufficient evidence on this point. Some of the extinct mammals, indeed, indicate a still lower horizon, or one nearly equivalent to the Lignite beds of France.

The Tertiary deposits in the Green River Basin are all of fresh-water origin, and of enormous thickness,—6000 feet at least. They are nearly or quite horizontal, and as a rule rest unconformably on the Cretaceous coal-bearing rocks below. The latter are in part brackish water beds, containing, with some characteristic Cretaceous fossils, many remains of plants, which have led Hayden, Lesquereux, and others to regard them as Tertiary. The evidence from the fossil plants is far from conclusive, while the Cretaceous age of essentially the same

* This Journal, vol. i, p. 191, March, 1871.

beds has been clearly made out at several different localities. At one of these, in 1870, the writer found above a seam of coal *Ostrea congesta* Conrad, a typical Cretaceous fossil, and a crinoid allied to *Marsupites* of the English Chalk. Below the coal, but in the same series, were remains of fishes and turtles, both of Cretaceous types, and teeth of a Dinosaur.* Nearly as conclusive evidence has since been found at other localities. In considering a question of this kind, where the evidence from fossils appears conflicting, it should especially be borne in mind that vertebrates afford a much more accurate guide to climatic and other geological changes than invertebrates, and vastly more so than plants.

This Eocene lake basin remained dry land during all of Miocene time, and perhaps much longer. It was then again submerged for a short period, and its eroded surface covered with water-worn debris from the surrounding mountains. The evidence of this is seen in the coarse conglomerate crowning the highest buttes, which have thus escaped in part the enormous denudation most of the deposits in this basin have suffered.

South of the Uintah Mountains, a second and larger lake existed in the Eocene. It was 2,000 feet or more lower than the northern lake, and received part of its waters from that source. It had the Rocky Mountains for its eastern border, the Wasatch range on the west, and extended from the Uintahs far to the southward, doubtless quite to the present territory of New Mexico. This basin was first explored, and its Eocene age established, in 1870, by the writer, who finding it distinct from the Green River basin on the north, named it the Uintah basin.† These two lakes were contemporaneous, for a long period at least, and undoubtedly were connected together east of the present Green River cañon. There is evidence that the southern lake continued for some time after the northern one dried up. The deposits of the Uintah basin are of very great thickness, and are underlaid by Cretaceous beds, in some places much inclined.

The fauna entombed in both these Eocene lakes is essentially the same, and indicates a tropical climate. This is seen especially in the great number of Tapiroid mammals, monkeys, crocodiles, lizards and serpents. Remains of *Dinocerata*, the largest of Eocene mammals, have as yet been found only in the northern basin, and there are some other important differences at present, which future discoveries may remove.

There are indications of another Eocene lake in Eastern Oregon, west of the Blue Mountains, but as only a few plants have hitherto been found in its deposits, its relations in time to the great central Eocene lakes cannot as yet be determined.

* This Journal, vol. i, p. 195, March, 1871. † Loc. cit., p. 196.

II. *Miocene Lake-basins.*

The Tertiary lake-basin first made known in the Rocky Mountain region is that south of the Black Hills, so long famous for its "*Mauvaises Terres*" or "Bad Lands," and for its wonderful vertebrate fauna, which Prof. Hayden has done so much to bring to light. This ancient lake, which was comparatively shallow, appears to have extended south from the Black Hills to near where the Republican River now is, or from about the 44th to the 40th parallel of latitude. Its western border was the Rocky Mountains, and its eastern margin probably not far from the 99th meridian. The strata in this basin are all nearly horizontal, and indicate quiet waters. They are lighter in color, and much less arenaceous than those of the Eocene lakes. The best exposures of these Miocene beds are seen near the White River, and this name has very appropriately been used by Prof. Hayden to distinguish the lake basin in which they were deposited. In Northeast Colorado the same formation is well developed. The "Bad Lands" there were discovered and first explored by the writer in 1870.* These Miocene strata rest, with more or less unconformity, on an extensive series of lignite-bearing beds, which in many respects resemble those beneath the Eocene basins. The age of these beds, also, is in dispute, but the remains of Dinosaurs and some other typical Mesozoic vertebrates, which have now been found at many widely separated localities, leaves little doubt that they should be placed in the Cretaceous, the great coal-bearing formation of the Rocky Mountains.

After this Miocene lake was filled up, and its surface more or less eroded, a great subsidence took place, and a second larger lake was formed, in which extensive beds of clay and sand were deposited over the same area. As both series of strata are essentially horizontal, and of nearly the same color, the dividing line in many places can be made out only by means of the vertebrate fossils they contain. In this way, the writer has recently ascertained, by personal observation, that most of the upper beds (D and E), 500 feet at least in thickness, which were called Miocene by Prof. Hayden,† are deposits of the more recent Pliocene lake. This would leave for the true Miocene beds a thickness of about 300 feet. The upper strata will be again referred to in considering the Pliocene lake.

The fauna of the White River lake-basin is now well known to naturalists. It indicates a climate much less tropical than that of the Eocene lakes, as is seen in the absence of monkeys and scarcity of reptilian life. The *Brontotheridæ*, the largest known Miocene mammals, are peculiar to the lower strata of this basin. They fully equalled the Eocene *Dinocerata* in size.

* This Journal, vol. l, p. 292, Sept., 1870.

† Transactions American Phil. Soc. vol. xii, p. 105, 1862.

A still more ancient Miocene lake existed, in about the same latitude, on the Pacific slope, near the central part of the present State of Oregon. The Blue Mountains formed the eastern and southern shores of this lake, but its other limits are difficult to ascertain, as this whole country has since been deeply buried by successive outflows of volcanic rocks. It is only where the latter have been washed away that the lake deposits can be examined. The discovery and first explorations in this basin were made by Rev. Thomas Condon, the present State geologist of Oregon. The typical localities of this Miocene basin are along the John Day River, and this name may very properly be used to designate the lake-basin. The strata in this basin are more or less inclined, and of great thickness. One section, near the John Day River, examined by the writer in 1871, and again in 1873, seems to indicate a thickness of not less than 5,000 feet. The upper beds alone of this series correspond to the deposits in the White River basin. The lower portion also is clearly Miocene, as shown by its vertebrate fauna, which differs in many respects from that above. Beneath these strata are seen, at a few localities, the Eocene beds containing fossil plants, mentioned above. They are more highly inclined than the Miocene beds, and some of them show that they have been subjected to heat. The inferior strata elsewhere are Mesozoic, and apparently Cretaceous. Above the Miocene strata, Pliocene beds are seen in a few places, but basalt covers nearly all.

III. *Pliocene Lake-basins.*

At the close of the Miocene, a subsidence took place east of the Rocky Mountains. A great Pliocene lake was thus formed directly over the eastern Miocene basin, having nearly the same boundaries on the north and west, but extending much farther east, and stretching south nearly to the Gulf of Mexico. It covered an area at least five times as great as the older lake, while its deposits attained a thickness of nearly or quite 1,500 feet. This lake basin may with great propriety be called the Niobrara basin, since the Niobrara River cuts through its typical strata for more than 200 miles of its course.

The beds in this basin lie nearly horizontal. They are light in color, and much more arenaceous than the Miocene below. The upper strata consist of hard sandstones or calcareous grits, which weather but slowly, and hence still form the great table-lands over much of the area of the basin. The writer has traced these high plateaux and the intervening isolated buttes from near the Black Hills south to the Arkansas River, and found them all of Pliocene age. South of the Smoky Hill River these strata rest directly on the Cretaceous.

The fauna of this lake-basin indicates a warm temperate climate. The more common mammals are a mastodon, rhinoceroses, camels and horses, the latter being especially abundant.

[To be continued.]

SCIENTIFIC INTELLIGENCE.

I. Physics.

1. *Theory of Electricity.*—Mr. E. Edlund has published in full his theory that electricity is identical with the luminiferous ether. He first shows that the velocity h, with which the ether particles move, differs from v, the velocity with which this motion is propagated; h depends on the current and increases with it, while v depends on the ratio of the electricity to the density, but is independent of the current. It is the velocity v which Wheatstone, Fizeau and others have attempted to measure. The objection to this theory raised by MM. Roiti and Herwig are due to their overlooking the differences in these velocities.

The memoir deduces theoretically Ampère's general formula and the law of the division of the current between several conductors, when these contain electro-motive forces. Kirchhoff's laws are therefore an immediate consequence of the proposed theory. The heating produced by a galvanic current and by an electric battery are also given. The law for the duration of the discharge has also been deduced, and agreed with that found experimentally by M. Reiss. The oscillatory discharge of a battery and the phenomena of Peltier again give the same result as that deduced experimentally; and the same may be said of the laws experimentally established by Wiedemann for the transport of liquid in the direction of the galvanic current and for currents through a diaphragm, discovered by M. Quincke.

As to the rotation of the plane of polarization of light by a current, M. C. Neumann has shown that it can be explained satisfactorily if we admit that the molecular currents of Ampère act upon the molecules of ether in vibration precisely as if these last were electric molecules. The demonstration is based on the formula given by Weber for the action of an element of a current upon an electric molecule in motion. But as, according to Edlund, the electric fluid is nothing but the ether itself, evidently Neumann's hypothesis is confirmed, since according to the views of the author the molecular currents of Ampère are merely currents of ether.

The author says, in conclusion, that the theory proposed explains satisfactorily all the electric phenomena for which one can demand an explanation, based simply on such a theory. The explanation of many phenomena evidently demands the knowledge of the laws of other forces than electricity, since they unite with it in producing the phenomena in question. For instance, Faraday's law, that when a current traverses several electrolytes, the decompositions are proportional to their chemical equivalents, requires for its theoretical proof a much more exact knowledge of chemical forces than we at present possess. It is not then in the nature of things that such a law can be deduced exclusively from a theory of electrical phenomena.—*Mem. Swedish Acad. of Sci.*, XII, No. 8; *Bib. Univ.*, ccii, 174. E. C. P.

2. *Electrostatic Induction.*—M. NEYRENEUF has repeated with a Holtz the experiments of MM. Verdet and Masson, to determine the direction of the induced current with the electric egg. Two Matteucci disks contain, one the inducing, the other the induced spiral. This latter is put in connection with the two extremities of a cylindrical Geissler tube 50 cms. long. The first spiral is connected by one end with the negative armature of the machine, while the other is attached to one plate of a condenser with air film, whose collector communicated with the positive armature. The spark leaps between the two armatures of the machine from which the condensers have been removed. Two currents in opposite directions traverse the inducing spiral under these conditions, the one to charge, the other to discharge the condenser. Those produced in the second spiral illuminate the Geissler tube very brilliantly.

With an explosive distance of 5 cms. we observe clearly the difference in appearance of the two poles; but we can, by diminishing it continuously, produce three separate inversions at the instants when the appearance of the two poles is identical. When the striking distance is 3 cms. large and widely separated stratifications are formed, but presenting before the last inversion all the characters produced by a Ruhmkorff coil. The same effects are produced by altering the distance of the spirals or of the plates of the condenser. These condensers show that the phenomenon in question bears no relation to the lateral discharge, characterized especially by the constancy of the direction of the current it produces.—*Comptes Rendus*, lxxix, 1071. E. C. P.

3. *Effect of Flame on an Electric Spark.*—Mr. S. J. MIXTER notices a curious effect of a gas flame on the current of a Holtz machine. The jet consisted of a glass tube drawn out to a point, and the flame had a length of about an inch and a diameter of only an eighth of an inch. Inserting this between the two terminals of the machine, the length of spark obtainable was at once increased from less than ten inches to over twelve, the full distance to which the balls could be separated. The same increase was not obtained by simply inserting a conductor between the two terminals, a ball an inch in diameter only lengthening the spark about an inch.

E. C. P.

4. *Laws of Tuning Forks.*—M. MERCADIER has determined experimentally the effect of a change in the dimensions of a tuning fork on its number of vibrations. A style is attached to the end of the prong and draws a sinuous line on a revolving cylinder covered with lampblack. Another style attached to an electromagnet registers the beats of a clock giving seconds. The vibration of the fork is maintained electrically. By the thickness of prong is meant its dimension parallel to the vibrations, by its breadth, the perpendicular direction. A fork having a breadth of 35·3 mms. gave 144·7 vibrations. Reducing its breadth to 30·9 and 24·8 it still gave 144·7 and 144·9 vibrations. Hence the number of vibrations is independent of the breadth. A similar meas-

urement was made with different thicknesses from 20·25 mms. to 4·37 mms. and showed that the number of vibrations was nearly proportional to the thickness. A fork three decimeters long was then shortened 20 mms. at a time and the vibrations measured in each case. The length of the prong being altered from 295 to 57 mms., the number of vibrations increased from 40 to 974. Hence the vibrations are inversely proportional to the square of the lengths, calling the latter the projection of the line bisecting the prong, or the axis plus a small quantity y, which in this case equalled 3·8 mms. These laws may be written in the form of the equation $n = \frac{Ke}{(l+y)^2}$, in which n is the number of vibrations, e the thickness, l the length, y a small constant, and K a constant depending on the material. For steel, K=818270. To compare this constant with theory, K was computed from the formula for the number of vibrations of an elastic bar in terms of v, the velocity of sound in it; taking v=4985 m., according to the experiments of Wertheim; K in this case became 820131, a result differing from that previously obtained by only a fifth of one per cent. The number of vibrations of three forks were found by measurement to be 144·7, 77·7, 29·7, and by the formula 146·4, 79·0, 29·0. Hence forks may be made by calculation to give any desired number of vibrations within one or two per cent.—*Comptes Rendus*, lxxix, 1001, 1069. E. C. P.

5. *Polarization of Light;* by WILLIAM SPOTTISWOODE, M.A., LL.D., F.R.S. 130 pp. 12mo. London: 1874. Nature Series. (Macmillan & Co.)—This small treatise on the Polarization of Light, as the Preface states, contains the substance of lectures delivered by the author at various times to his work-people, and "constitutes a talk rather than a treatise on Polarized Light." The fundamental principles of the subject are explained in a simple manner, and are well illustrated by means of two beautifully colored plates, besides a number of wood-cuts.

II. GEOLOGY AND NATURAL HISTORY.

1. *Earthquakes of North Carolina.*—An excellent article on earthquakes in the mountain region of North Carolina has been published by Hon. T. L. Clingman in the *Western Expositor* of Asheville, N. C. He states that more than thirty years since his attention was called to statements that a mountain in the northern part of Haywood County was shaken at intervals of two or three years; and in 1848 he visited the region and published a paper on it. The principal facts stated were these:

Between the Blue Ridge, which in North Carolina separates the waters falling into the Atlantic from those discharged into the Mississippi, and the great chain on the Tennessee border designated in its course by such names as Iron, Unaka, and Smoky, there is an elevated plateau of over two hundred miles in length, with an average breadth of fifty miles. The beds of the larger streams

are two thousand feet above the sea, and the general level of the country, exclusive of the mountain ranges, may be estimated at twenty-five hundred feet above tide-water. Haywood County joins the State of Tennessee on its northern border, and the seat of the disturbance is within less than twenty miles of the line of that State. A considerable range of mountains extends north and south along the line which separates the counties of Buncombe and Haywood. From the west side of this extends a ridge, which terminates near the head of Fines Creek. A quarter of a mile from its western end, as one moves up it toward the east, is the locality referred to. The effect of the disturbance is visible near the crest of the ridge and extends in a direction nearly south, down the side of the little mountain, four or five hundred yards, to the level ground, and across it for some distance and along the elevations beyond. The whole extent may be a mile in length, with a breadth of not more than a couple of hundred yards at any point. The top of the ridge, where evidences of violence are seen, is perhaps three or four hundred feet higher than the ground below. There are cracks in the solid granite of which the ridge appears to be composed, but the chief evidences of violence were observable a little south of the crest. From thence along the side of the mountain, as one descends, there were chasms, none of them above four feet in width, generally extending north and south, but also occasionally seen in all directions. All the large trees had been thrown down. There were a number of little hillocks, the largest eight or ten feet high and fifty or sixty feet in diameter. They were usually surrounded by what appeared to have been a narrow crevice. On their sides the saplings grew perpendicularly to the surface of the ground, but obliquely to the horizon, making it manifest that they had attained some size before the hillocks had been elevated. I observed a large poplar or tulip tree which had been split through its center, so as to leave one-half of it standing thirty or forty feet high. The crack or opening under it was not an inch wide, but could be traced for a hundred yards, making it evident that there had been an opening of sufficient width to split the tree, and that then the sides of the chasm had returned to their original position without having slipped, so as to prevent the contact of the broken roots.

When I was there I was told that three years had elapsed since the last previous shock. They were first noticed about the year 1812, and usually repeated at intervals of two or three years. In 1851 I visited the locality again, having been informed that a feeble jar had occurred. As soon as I arrived at the locality, I was struck with the truthfulness of what many persons had told me, that after each shock the appearance of the place was so much changed that it did not at all resemble itself. On this occasion, though the shock had been a feeble one, I found the appearances very different. The greatest evidences of violence were near the foot of the ridge, the branch having been somewhat turned out of its course. Near this place a rock of considerable size had been

thrown up and had only partially settled back, owing to the closing of the opening under it, so that the former earth marks were seen several feet above the ground on its sides.

In the year 1867 I saw the locality again. A number of shocks had in the meantime occurred, and the appearances were very different from what they had been. From the top of the ridge to the base it seemed a mass of rocks, most of the earth having been carried away. The depression at the top was greater, while the successive jars had, under the action of the force of gravity, moved the mass downward, and had forced the stream still further away from the hill. The violence had at one point extended itself a little further to the east. A large oak tree of great age and four or five feet in diameter had been entirely split open from root to top, and thrown down so that the two halves lay several feet apart.

In my former publication, it was suggested that if the phenomena at this point were due to volcanic action, similar disturbances would be noticed at other localities in the Alleghany range. I was soon informed that three or four years previously, in the southeastern part of Macon County, between the Tuckasegee River and the Cowee Mountain, the ground was shaken violently for several minutes. A few days afterward some persons discovered a fresh chasm, two or three feet wide, which extended more than a mile. This was in the month of June, and they said the leaves and branches of timber immediately above the chasm, in places, presented the appearance of having been scorched. Though I was not able to visit the place, yet from the character of my informants I do not doubt but that the facts were as above stated.

I have also been informed that in the county of Cherokee, in the year 1829, or thereabouts, the Valley River Mountain was cleft open for a considerable distance, during a violent shaking of the earth in that vicinity. The chasm, though partially filled up, is represented as still visible.

Mr. Silas McDowell, of Macon County, a highly respectable and intelligent gentleman, accustomed to observe and write on such subjects, has stated recently in a paper published at Asheville, that many years since there was a violent shock in the neighborhood where he resides, during which a chasm was opened on the north side of the mountain which separates the Ellejay waters from those of the Sugar Fork River. He states that the opening is still visible. This locality is eight or ten miles to the southeast of Franklin, in Macon County.

About three years since I heard from many persons, that for several weeks smoke continued to issue from a small crevice in the rock, in Madison County. Not long afterward I went to the place, and though the smoke had previously ceased to issue, yet there was evidence that the locality had at some time, probably during the present century, been subjected to violence, that had changed the outlines of the ground and surface rocks. This spot is about fifteen miles east of the Haywood Mountain, and about as far from the Warm Spring to the northwest of it.

Lastly, we have to notice the disturbance of the Bald and Stone Mountains. They are situated six or eight miles to the east of the Blue Ridge. Between the headwaters of the Catawba and those of Broad River, there extends many miles eastward a range of mountains attaining the height in places of four thousand feet. The Bald and Stone Mountains, from their appearance, are probably the highest part of this ridge, and nearly equidistant from the Catawba and Broad Rivers. My information in reference to them is derived entirely from conversations with a number of gentlemen, and from the accounts published in the newspapers. The first shocks were perceived on the 10th of February last, and they were for the first month or two more frequent than they have since been. During the last two months they have occurred at intervals of a week or two, but have been rather more violent than the average. Within the last five months probably a hundred shocks, accompanied with noises, have occurred.

The distance from this point to the Valley River Mountain, in Cherokee, nearly due west, is more than one hundred miles in a direct line. From the mountain in Haywood, to reach the parallel of latitude passing through the mountain near Ellejay, in Macon, one must travel more than thirty miles south. It is thus manifested that there is a belt of country more than a hundred miles in extent from east to west by thirty in breadth in which such disturbances have been observed. In the present state of scientific knowledge, it may not be an easy task to offer an explanation of the causes which will be generally accepted as satisfactory.

When we take into account these indications at different points in the North Carolina mountains, it seems evident that there is beneath the surface a condition of things that extends over a considerable area. A portion of the globe which, from its geological structure, ought to be regarded as being as stable as any part of our planet, is nevertheless not free from change. Whether this is to be regarded as due to the diminishing force, which at one time was sufficient to heave up this tract of country, with all its mountain chains, or whether it is to be considered as evidence of a gradual return of that volcanic action which manifests itself still elsewhere, to so great an extent, it is perhaps difficult to decide until further observations have been made. Is it not of sufficient interest to justify the managers of the Coast Survey, or some other competent agency, to make such careful measurements of the height of certain points, as to ascertain, within the next twenty-five or fifty years, whether any, and to what extent, changes may be occurring in this region?

2. *Porphyry of the Island of Lambay, a few miles north of Dublin Bay.*—Professor Edward Hull finds this green porphyry (Geol. Mag. for Oct., 1874) to consist of a felsitic base, which is penetrated throughout with grains of a chloritic mineral and magnetite, and crystals of orthoclase. Minute cavities have sometimes clusters of crystals of magnetite on the inner surface, and chlorite, or calcite, or both, in the interior. The

chlorite is regarded by the author as of secondary origin, and as "introduced by the agency of water, which has permeated the whole mass of the rock through channels inconceivably narrow." The calcite is diffused throughout the rock and also in its minute rifts and cavities, and the author remarks also that "it is unquestionably due to infiltration;" adding that "it is easy to conceive that water percolating downward through to the limestone and the thin coating of Old Red Sandstone beneath, would become thoroughly impregnated with carbonate of lime, which it would deposit amongst the fissures and cells of the older rocks beneath."

As urged in this Journal, vol. vi, p. 107, with reference to the Mesozoic trap of the vicinity of New Haven, Connecticut (and applied also to other traps or dolerytes), it seems to be quite certain that the chlorite in the above mentioned porphyry, and in igneous rock generally, was not only derived from ingredients in the rock, but was made through the agency of water that gained admission from some subterranean source *when the melted rock was ascending to the surface;** that the same is true for other hydrous minerals disseminated through the mass of any igneous rock, for example, the zeolitic, in phonolytes. The same kind of evidence sustains, as stated in the same place, the conclusion that all amygdaloidal rocks owe the cavities which they contain (the cavities occupied by the amygdules), and a large part of the zeolitic and other minerals in the cavities, mainly to the action of the same waters on the rock—first while melted and then while cooling from a state of fusion. Further, such waters may have carried into the cavities not only hydrous minerals, but also anhydrous. Melted rock rising in a fissure would take in also any gas or vapor that was evolved by the heat from rocks adjacent to the fissure, and would thus become more or less penetrated with the gas or vapor, and by this method carbonate of lime might have been made with any lime in the rock, if carbonic acid were the gas received, or other minerals with the aid of other vapors, even, it might be, metallic ores. If cavities exist they are sure to become filled, because all solutions would pass into them and keep depositing until they were full; and the rock, if the cavities were numerous, might thus be drained of a large part of the minerals formed, the chlorite excepted. These cavities have no doubt sometimes received mineral material from infiltrations of later date, but not so the body of the rock. J. D. DANA.

3. *Geological and Topographical Survey of the Territories.*—Concerning the work of the season just ended, the Secretary of the Interior makes the following Report to Congress:

"The first division of the survey under Mr. Hayden completed the unfinished work of the preceding season in the central portion of Colorado Territory, and extended its operations westward over that portion of said territory lying between the one hundred and

* The conclusion, as far as it regards the trap of the Connecticut Valley, is sustained by the microscopic researches of Mr. E. S. Dana, an abstract of whose paper is given on page 390 of the last volume of this Journal.

eighth and one hundred and tenth meridians of west longitude. About eighteen thousand square miles were surveyed, covering a section of country probably more generally elevated above the sea-level than any other within the borders of the United States. As an illustration of the uniform great elevation of extensive sections of this region, it may be mentioned that one of the subdivisions of the survey, in exploring an area of nearly three thousand square miles, was compelled to operate above the timber-line (about 11,500 feet above the level of the sea) for over a month. The necessary materials have been collected for constructing accurate maps of the region surveyed, which will require for illustration six sheets or maps of the physical atlas. Special attention was given to the mining and agricultural resources of the country, and those portions of it which can be redeemed by irrigation will be properly indicated on the maps. The San Juan mining region in southern Colorado was included in the survey, and over fifty mines therein were properly located. Many valuable specimens of ores, minerals, fossils, Indian art, &c., were collected. Numerous ruins of towns and dwellings of an extinct race of people which once inhabited the mèsas and cañons of western Colorado were found, and remarkable fortifications of hewn stone laid in mortar discovered in the sides of deep cañons, many of which are situated a thousand feet vertically from the stream below. The structure of these fortifications and dwellings, and the peculiar glazed pottery in the vicinity, indicate the existence of a people inhabiting this region many centuries ago, who were much further advanced in the arts than any of the Indian tribes of the present day. The results of the work of the past season will exceed in quantity and interest those of any previous year.

The field of operations during the past season of the second division, under Mr. Powell, was the central and northeastern portions of Utah Territory, and its labors were principally confined to the completion of the unfinished work of the preceding year. The main party is still in the field, so that the full results of the season's survey cannot at this date be given. It may be stated, however, that material has been collected for the mapping of an extensive region of country heretofore but little known; that the positions of many of the more important mineral lodes have been determined, and will be represented on the "general" maps; and that the area and distribution of such portions of the country surveyed as can be redeemed by irrigation will be properly indicated on the "special" maps. Extensive coal-beds have been discovered and traced, interesting and valuable specimens of fossils, rocks, minerals, and ores obtained, and a large collection made of Indian relics and articles, illustrating the arts existing among the Indians inhabiting that region. Mr. Powell had, in former surveys, discovered many ruins of towns and hamlets once occupied by the ancient inhabitants of the valley of the Colorado River; and during the past season many other such ruins have been found, some of their ancient picture-writings and many of their

stone implements collected. The positions of many scores of these ruined towns will be accurately indicated on the "general" maps. The researches of this division among the extinct races, as well as the present inhabitants of this interesting region, have embraced polity, mythology, traditions, language, poetry, arts, habits, customs, and the means of obtaining subsistence, together with pre-historic remains; and when the results obtained shall have been published, it is believed that they will constitute an important contribution to the ethnography of American tribes.

These surveys have, so far as they have been prosecuted, resulted in affording much information of great value to our people, as well as to the scientific world. The construction of a physical atlas of the Territories, which will show all the results of the surveys as rapidly as they can be prepared for publication, is designed to preserve, for convenient reference, the information thus obtained; and if a continuation of the surveys should be authorized, such an atlas would become, in time, of intrinsic value, not only to the people at large, but to other nations.

In view of these and other considerations, I regard the moderate cost of these surveys as more than compensated by the value of the information thereby obtained, and therefore cordially recommend a continuation of the United States geological survey of the Territories."

The many photographs taken by the artist, Mr. Jackson, during the past season, are admirable specimens of the photographic art. There is not as bold scenery as in some Rocky Mountain views, but there is wonderful beauty of landscape, which is heightened by the perfect aerial perspective given the pictures and the well-selected foreground. Lakes, rivers, cañons, hills, eroded strata, mountain ridges and distant snowy ranges, are the different elements in the views. They are from the Middle Park, the Grand River region and other places. A considerable number of them represent cave-dwellings high up on cliffs, in the cañon of the Mancos, and near the McElmo, and ruins of walls and other structures of stone in the vicinity of the same—the dwellings and fortified places of a semi-civilized race now extinct.

4 *On the more rapid deposition of Sediment in Salt than in fresh water.*—Prof. T. Sterry Hunt, in a recent article in the Proceedings of the Boston Natural History Society, calls attention to the fact that the effect of salt in water on the rate of deposition was first mentioned by Mr. Slidell, in Humphrey and Abbott's Report on the Mississipi River, and then explains it on the ground of the less cohesion between the particles of salt water, as proved by the fact that drops of salt water are smaller than those of fresh water.

5. *Artesian boring at the St. Louis Insane Asylum.*—Mr. G. C. Broadhead, State Geologist of Missouri, gives the details respecting this boring, in the Transactions of the St. Louis Academy of Sciences, vol. iii, 216. The whole depth is 3,843·5 feet; of this the last 40 feet were through Archæan granite; above, the beds

were of the Lower Silurian and Carboniferous formations. The Carboniferous at the well had a thickness of 873 feet—80 of it Coal-measures, 670 feet Subcarboniferous, 93 feet Choutean group (referred by most authors to the Subcarboniferous, and called in Iowa and Illinois the Kinderhook group). The Lower Silurian, beginning above, consists of Trenton 421 feet; first magnesian limestone 148 feet; sandstone (called saccharoidal sandstone, used in glass-making) 133 feet; second limestone 517 feet; second sandstone 82 feet; third limestone 838 feet; third sandstone 98 feet; fourth limestone 384 feet; fourth sandstone, called Potsdam, 299·5 feet. Salt water was obtained (in place of fresh) at 1,220 feet, and a sulphur water at 2,140 feet. At 2,256 the water in the sand-pump indicated 3 per cent of salt; at 2,957 feet, 4½ per cent; at 3,293 feet, 2 per cent; at 3,367 feet, less than 2 per cent; at 3,384 feet, 3 per cent; and below 3,545 feet, 7 to 8 per cent. With a Fahrenheit self-registering thermometer, the temperature obtained at depths from 3,127 to 3,837 varied from 107° to 104½°, being 105° at the lowest point reached.

In an artesian well at Belcher's sugar refinery, St. Louis, salt water was obtained at 610 and 849 feet below the surface at the place, or 790 and 1,029 feet below the level of the surface at the asylum well.

6. *Return of Professor Marsh's Expedition.*—Professor MARSH returned to New Haven, Dec. 12th, after an absence of two months in the West. The object of the present expedition was to examine a remarkable locality of fossils, discovered during the past summer in the Bad Lands south of the Black Hills. The explorations were very successful, notwithstanding extremely cold weather and the continued hostility of the Sioux Indians. The latter refused to allow the expedition to cross White River, but a reluctant consent was at last obtained. They afterward stopped the party on the way to the Bad Lands, attempted a night attack on their camp, and otherwise molested them, but the accompanying escort of United States troops proved sufficient for protection. The fossil deposits explored were mainly of Miocene age, and, although quite limited in extent, proved to be rich beyond expectation. Nearly two tons of fossil bones were collected, most of them rare specimens, and many unknown to science. Among the most interesting remains found were several species of gigantic *Brontotheridæ*, nearly as large as Elephants. At one point these bones were heaped together in such numbers as to indicate that the animals lived in herds, and had been washed into this ancient lake by a freshet. Successful explorations were made, also, in the Pliocene strata of the same region. All the collections secured go to Yale College, and will soon be described by Professor Marsh.

7. *Survey of the 40th Parallel.*—The preparation of the final reports on this Survey, by CLARENCE KING, is in rapid progress, and their publication is expected to go forward during the present year. Prof. ZIRKEL, of Leipsic, was in the country during the month of September, at Mr. King's solicitation, to examine rock

specimens, and to take for study the thin sections of the rocks which had been made—more than a thousand in number—and will prepare a report upon them for publication in the 40th Parallel series.

8. *Geological Sketch of the State of Missouri, illustrated by maps;* by GEO. C. SWALLOW, A.M., M.D., late State Geologist, and Prof. Agric., Geol. and Bot. in the Univ. of the State of Missouri. 10 pp. large 4to. St. Louis, 1873. (R. A. Campbell.) This sketch by Professor Swallow presents a brief review of the Geology of the State of Missouri and is accompanied by a colored section and a colored geological map. The section makes the third and fourth magnesian limestones, with the intervening sandstone, equivalents of the Primordial.

9. *Das Elbthalgebirge in Sachsen* of Dr. GEINITZ.—The fifth number of Part II has been issued by the publisher, T. Fischer, of Cassel. It contains the Gasteropods and Cephalopods, with plates 29 to 36 inclusive.

10. *Preliminary Notice of Chondrodite Crystals from the Tilly-Foster Iron Mine, Brewster, N. Y.;* by EDWARD S. DANA.—The occurrence of chondrodite in large quantities at the Tilly-Foster Iron Mine has already been described by Professor Dana in an article upon "Serpentine Pseudomorphs," published in the two preceding numbers of this Journal. In addition to the common massive variety of the species, and that occurring in large coarse crystals, there have been found also, though very rarely, some small but very fine crystals, admitting of the most accurate measurements. These crystals are of a rich garnet-red color, with absolutely faultless luster, and are modified by a very large number of planes. The special interest of chondrodite arises from its relation to, or more properly identity with, the Vesuvian humite, whose remarkable crystallographic character in its three types of forms has been made known in full by the labors of Secchi and vom Rath. Kokscharow has shown that the chondrodite of Pargas is identical in angle with the *second* type of humite, and vom Rath has since obtained the same result for the Swedish specimens. The examination of the Brewster crystals, which I have been carrying on for the past few months, shows that they also belong, for the most part, to the *second* type, though among a considerable number of crystals I have identified also representatives of *the third type.* A few angles will show how close is the resemblance to the humite. (The letters for the planes are those used by vom Rath.)

	II Type.		III Type.	
Humite (v. Rath).		Chondrodite (E. S. Dana).	Humite.	Chondrodite.
$A : \frac{1}{3}r$	135° 18′	135° 19′	$A : \frac{1}{3}r = 111°\ 51'$	111° 49′ 111° 44′
$A : \frac{1}{2}r$	125° 49′	125° 50′	$A : i = 109°\ 28'$	109° 25′
$A : e$	108° 58′	109° 3′	$A : \frac{1}{2}i = 125°\ 15'$	125° 13′
$A : i$	122° 28′	122° 28′		

The planes, which occur constantly, are the same that are found on humite, and the kind of hemihedrism is the same. This is true

for both types; thus in type II the planes identified on chondrodite are A, B, C, $+r$, $+\frac{1}{2}r$, $-\frac{1}{2}r$, $-\frac{1}{4}r$, n, $\frac{1}{2}n$, $-m$, i, e, $\frac{1}{2}e$, etc. Type III, chondrodite, $+r$, $+\frac{1}{2}r$, $+\frac{1}{3}r$, $-\frac{1}{3}r$, $-\frac{1}{4}r$, $-\frac{1}{11}r$, n, $\frac{1}{3}n$, $\frac{1}{4}n$, i, $\frac{1}{3}i$. etc.

In addition to these prominent planes, I have measured, and more or less surely determined, upwards of a *hundred* other planes, very minute, and yet flat and giving in many cases perfectly reliable angles. As would naturally be expected, the indices of these planes are in general anything but simple. The discussion of these, and the description of other points of interest which have been observed, including several twins, must be deferred till the final completion of the memoir, which, it is hoped, will not be long delayed.

11. *Livingstonite.*—This mineral, recently described by Señor M. Bárcena (see this Journal, last vol., p. 145), has been analyzed by its describer with the following results: Sulphur 29·08, antimony 53·12, mercury 14·00, iron 3·50 = 99·70; whence the atomic ratio for the sulphur, antimony, mercury and iron 18·17 : 8·7 : 1·4 : 1·2 = (nearly) 15 : 7 : 1 : 1.

The livingstonite occurs at Huitzuco, in the State of Guerrero, in a matrix of carbonate and sulphate of lime, along with native sulphur, cinnabar, valentinite and stibnite. The author mentions the occurrence of some specimens of cinnabar at the locality which have the form of livingstonite, and which, therefore, are pseudomorphous.

12. *On Dawsonite, a new mineral;* by B. J. Harrington, Chemist and Mineralogist to the Geological Survey of Canada. (Canadian Naturalist, vii, August, 1874.)—Dawsonite is from a whitish felsitic dike near the western end of McGill College, Montreal. Hunt obtained for the rock (which he calls trachyte), after separating 9·55 by nitric acid (Geol. Can., 1863, 659, 660), silica 63·25, alumina 22·12, lime 0·56, potash 5·92, soda 6·29, volatile 0·93=99·07. The portion dissolved out by nitric acid contained: Silica 1·43, alumina 2·43, peroxide of iron 2·40, red oxide of manganese 1·31, lime 0·60, potash 0·40, soda 0·98=9·55. In the joints of this rock occurs a white-bladed mineral, which is the Dawsonite.

The following are its characters. Hardness 3; G=2·40; luster vitreous; transparent to translucent. The blades are somewhat fibrous in structure, and the crystallization is probably monoclinic, with the inclination of the vertical axis about 75°. It shows bands of colors in polarized light. B. B. becomes opaque and often exfoliates or swells into cauliflower-like forms. In the closed tube yields water and carbonic acid. Dissolves completely in cold dilute hydrochloric or nitric acid. Two analyses, made at different times, the last from portions of several specimens, afford Mr. Harrington—

$\dot{S}i$	$\dot{C}$	$\dot{A}l$	$\dot{M}g$	$\dot{C}a$	$\dot{N}a$	$\dot{K}$	$\dot{H}$
0·40	29·88	32·84	tr.	5·95	20·20	0·38	11·91=101·56.
——	30·72	32·68	0·45	5·65	20·17		[10·32]=100.

Mr. Harrington inclines to the conclusion that the mineral is a hydrous carbonate of alumina, lime and soda; and that it is related therefore to hovite, which the Messrs. Gladstone made a carbonate of alumina and lime. Its crystalline character and its uniformity in optical and chemical characters show that it is not a mechanical mixture.

13. *Tables for the Determination of Minerals, by their Physical properties, ascertainable by the aid of such simple instruments as every student in the field should have with him.* Translated from the German of WEISBACH. Enlarged, and furnished with chemical formulas, a column of specific gravities and one of the characteristic Blowpipe reactions; by PERSIFOR FRAZER, Jr., A.M., Assist. Geol. in the Second Geol. Survey of Pennsylvania, etc. 118 pp. 8vo. Philadelphia, 1875. (J. B. Lippincott & Co.)—All helps to the determination of minerals will be welcomed by the student in the science, and Weisbach's tables are among the best of those based chiefly on the physical characters. We notice that the species of minerals that are peculiarly American are mostly omitted, and many of the recently described foreign species; the addition of these will give increased value to another edition of the work. The volume is very clearly printed, on good paper.

14. *Notes on the Tree-Ferns of British Sikkim, with Descriptions of three New Species, and a few Supplemental Remarks on their Relations to Palms and Cycads;* by JOHN SCOTT, Curator of the Royal Botanical Gardens, Calcutta. This paper, recently published in the thirtieth volume of the *Transactions of the Linnean Society*, was read in Feb., 1870. It is illustrated by 18 plates, eleven of which relate to the structure of the stem, etc., a subject which is here treated with freshness and ability, as well as tersely, and to which interest is added by some ingenious speculations as to history and origin. In the concluding summary, considering the relationship of Ferns, "as founded on the structure of the stem," the author remarks: "First, then, they agree with Palms in their mode of growth and in the manner in which the leaves are arranged. I fail to see why the growth of the one should be termed endogenous, and the other acrogenous. If the peculiarity of endogeneity is the downward growth of a series of vascular bundles from the leaves in a curvilinear mode, from the interior to the periphery, not a few of the tree-ferns have very similar characteristics. In both, diametrically and longitudinally, growth is strictly apical; in both the stems are limited in their diametrical growth, and from the first traces of their formation the axial and peripheral developments are simultaneous; and as soon as the normal thickness has been attained, all further peripheral increase ceases, and the axis grows upward in a cylindrical form. In Palms the growing point is conical, and in tree-ferns terminally flattened; so that in the one case the nascent vascular bundles are almost horizontally arranged at the apex, in the other they are from the beginning vertical; but in both all cellular increase of the body of the axis has ceased ere the fronds have

attained their full development. Another point in which they agree is in the development of a system of free vascular bundles, which, originating in the apex of the stem, grow upward into the fronds and downward into the axis. In other respects they present many important points of difference, as in the free anastomoses of the fibro-vascular bundles, and the formation of a woody circle surrounding the central cellular axis, which, however, is partially represented in certain Palms (vide plate XII), as *Euterpe oleracea*, by a dense zone of vascular bundles, which very distinctly separates the central, in which the cellular tissue predominates, from the peripherical and essentially vascular. The tissues of this median zone are developed, I believe, exclusively from below upward, the growing points surrounding the apex of the stem and passing outward into the fronds. Dense though this zone is, the bundles do not, in any case that I have observed, inosculate with each other. Another important difference is presented in the passage of these bundles to the fronds. In Ferns, small ramifications of the bundles only pass into any given frond, while in Palms the entire bundle enters the frond. I need scarcely remark that there are also important differences in the minute structure of the woody bundles of Ferns and Palms, the former being much more simple, though apparently similarly limited in their period of growth. In thus noting the structural affinities and differences of the stems of tree-ferns and palms, I by no means ascribe to them an equal grade of organization; tree-ferns are decidedly inferior in rank. They have, however, sufficient in common to justify the opinion of their being differently diverged and progressed forms of a common ancestor, which must have been of great antiquity, considering that both apparently presented much the same characteristics in the Carboniferous epoch as they do now." (p. 28–29.)

The analogies between the monocotyledonous stem and that of *Nymphæa* is next referred to, and also of *Cacti* with *Cycas*. More practical is the author's correction of the current statement that *Cycas* has a circinate vernation, whereas *C. circinalis* and all the rest have a perfectly straight vernation, with only the leaflets involute. A. G.

15. *Flora Brasiliensis.*—Fasciculus 53, issued in April last, contains the *Polygaleæ*, by A. W. Bennett of London, 82 pages of letter press and 30 plates, a liberal allowance. *Polygala* is largely represented in the Brazilian empire, viz: by 86 species; *Monnina* by 11, and *Securidaca* by 18 species. *Krameria* is included in the order, and has six species. It was this latter genus, and not *Polygalaceæ* in the restricted sense, that the present writer thought nearer *Leguminosæ Cæsalpineæ* than to anything else in general floral structure, and he was disposed to regard the contrary position of the odd sepal and petal, and the simple carpel, as more important than they seem to subsequent authors; also, the floral structure of *Polygaleæ* most resembles *Sapindaceæ*. But, in fact the order is very peculiar.

Fasciculus 64, of the same work, issued in May, comprises the concluding half of J. Muller's elaboration of the Brazilian *Euphorbiaceæ*. This and fasc. 61 together comprise vol. xi, pars ii, a very substantial volume indeed, filled by this one order; 752 pages of letter press, 104 plates—a great undertaking, well and happily brought to a conclusion by the excellent botanist to whom this task was assigned. A. G.

16. *Journal of the Linnean Society*, No. 77, issued in October, contains ten papers, by Mr. Moseley and several others, collected under the general head of *Contributions to the Botany of the Expedition of H. M. S. Challenger.* They relate mainly to Marine Algæ and the maritime plants, and to Algæ from hot springs in the Azores. The value of the observations upon the vegetation of thermal waters is much diminished by the total lack of all record of the precise temperature of the waters in question.

A. G.

17. *Transactions and Proceedings of the Botanical Society.* Edinburgh. Vol. xi, part iii, 1873.—This part completes the eleventh volume of the series. It contains the President's (Prof. Wyville Thompson's) Address, delivered in November, 1872, a notable production, which was printed in some of the journals at the time, and excited much attention, being a lucid exposition of fermentation and putrefraction, and of the Mould-Fungi that produce and govern these decompositions. Biographical notices of the late Hugo von Mohl and of Andres Œrstedt are appended. Prof. William R. M'Nab contributes an elaborate paper on the organization of *Equisetum* and *Calamites.* Mr. Wilson's interesting paper here appears, in which he disproves the popular and long-current notion that Darnel grain is poisonous or even injurious. His paper was noticed in this Journal; but it may not be amiss to recapitulate, in the author's own words, that, after feeding upon the seeds himself freely, he concludes that, in his own case "darnel is not justly called *temulentum*;" its seeds and husks are not "infelix," are not "acrid," are not "unwholesome," are not "injurious," do not cause "delirium," do not produce "stupefaction," and are not "poisonous" nor productive of "fatal" results. Dr. Robert Brown (may he prove himself worthy of the name!) gives some notes upon Dichogamy and other allied subjects, instancing *Clerodendron Thompsoniæ* as an admirable example of "protandrous dichogamy;" the first time, so far as we know, in which this has been spoken of in Great Britain, although here long familiar. Other Clerodendrons show it, but none so beautifully. W. Ramsay Wright gives a digest of Dr. Eichler's well-known essay, entitled: "Are the Coniferæ gymnospermous or not?" These are only the more scientifically interesting articles.

A. G.

18. *Florida Plants.*—Dr. Edward Palmer made last year a collection of dried specimens of the plants of East Florida and the Keys. Four or five sets of these, named, are on sale, and may be ordered of S. Watson, Harvard University Herbarium, Cambridge. These sets range from 250 to 630 species, and cost $8 the hundred.

Dr. Palmer is now on his way to an exploration of the Islands of the southern part of California. A. G.

19. *The American Naturalist* closes its 8th volume with the December number just issued, and appeals for the moderately larger support needful to make this, our only natural history magazine, self-sustaining. We well understand what that means. When the paid-up subscription rises so as to cover the actual outlay in the production, the public should still take to heart the fact that all the scientific talent and effort, and the editorial labor, will still be unpaid for. The editors in this case are entitled to great credit for the zeal, perseverance and sacrifice with which they have kept this magazine, not only alive, but every year more worthy of life; let us add that they are also entitled to a more generous patronage. There are many more than the five hundred new subscribers for whom they now call, to whom the Naturalist would be of great use and interest. A. G.

20. *Botanical Necrology.*—On turning over the pages of the *Botanische Zeitung* for the year 1874 (received down to the end of November), we find no record of the death of any botanist, except that of Pritzel.

George Aug. Pritzel, of Berlin, was born in 1815, and died on the 14th of June last. His only botanical publication was a revision of the genus *Anemone*, contributed to the Linnæa in 1842. The valuable services which he rendered to the science, and which should preserve his memory, were by the faithful preparation of the indispensable *Thesaurus Literature Botanicæ* in 1851; of the *Iconum Botanicarum Index locupletissimus* in 1855, with a re-issue and supplement in 1866, and by the new edition of the *Thesaurus* in 4to, of which four parts, carrying the alphabetical portion of the work down to the word *Tournefort*, were issued in 1872. A severe illness, from which the author appears never to have recovered, interrupted the publication. This work and the *Iconum Index* are models of editorial and typographical excellence.

Rev. Richard Thomas Lowe, a much respected English botanist, born in 1802, who passed most of his life since 1828 in Madeira, and diligently investigated its botany, was lost at sea in April last, by the foundering of the Steamer Liberia, in which he was a passenger on his way to Madeira. His principal publications were the *Primitiæ Faunæ et Floræ Maderæ*, which appeared in the Cambridge Philosophical Transactions in 1830, with a supplement (*Novitiæ*, &c.) in 1838; and a *Manual Flora of Madeira*, begun in 1857, continued into the second volume in 1872, and left unfinished.

Mrs. Hooker.—With inexpressible sorrow we record the death of this excellent and accomplished lady, the wife of Dr. Hooker, Director of the Royal Gardens at Kew, and the President of the Royal Society, and the daughter of the late Professor Henslow. This sad event occurred on the 13th of November, of heart-disease. Of the great practical services rendered to science by most efficient aid to her husband we may not speak; but her name has of late become well known in Botany, through her able translation

of Le Maout and Decaisne's *Traité de Botanique*, for the English edition edited by Dr. Hooker.

JOHN TRAHERNE MAGGRIDGE (as the English journals at this moment inform us) died at Mentone, on the 24th of November, at the age of 32 years. His contributions to the Flora of Mentone, with its exquisite illustrations by his facile pencil, and not less admirable letter-press, his work on Harvesting Ants and Trap-door Spiders (published by Reeve & Co., London), and many short articles or notes in Nature and other journals, have made this charming young man's talents and keen powers of observation most favorably known to the scientific world. He has been for years an invalid, and took up his residence in the Riviera for the sake of a better winter climate than his native England. Here his scientific investigations have mainly been prosecuted,—were perhaps undertaken for the sake of occupation and interest during the slow progress of fatal pulmonary disease. A. G.

21. *Traité de Botanique conformé a l'état présent de la Science*, par J. SACHS; traduit de l'Allemand sur la 3^e^ édition et annoté par Ph. Van Tieghem. Paris, 1874. *Lehrbuch der Botanik*, 4^te^ Auflage, Leipzig, 1874.—The third edition of Professor Sachs's treatise was noticed in this Journal, May, 1873.

Professor Van Tieghem's translation and the new German edition are both revisions and demand a further notice.

The French revision is an accurate translation and displays great editorial skill. The entire treatise has been divided into topical paragraphs, to each of which a telling title has been given. In not a few instances, the heading embodies the substance of the section, and greatly increases the value of the book as a work of reference. This may be illustrated by a single chapter,—On the relation between the morphological nature of organs and their adaptation to the conditions of plant life. This chapter in the German edition occupies seven closely printed pages and has no division into subordinate sections, but in the translation the following headings are given:

Metamorphosis, adaptation and utility express one and the same fact, and are synonymous terms.

The same members of a plant can adapt itself to the most varied functions, and the same function can be performed by most widely different members.

Organic arrangements useful to the plant are reached by most varied adaptations.

Examples.—1. Vertical growth of the stem. Its utility. Different ways in which it is secured. By (a) Ascending stems. (b) Twining stems. (c) Climbing with tendrils, different adaptations of tendrils. (d) Stems climbing without tendrils.

2. Subterranean growth. Its utility. Different ways in which it is brought about.

3. Dissemination of seeds. The methods by which it is secured. There are gradual transitions in adaptations.

The editorial notes communicated by Professor Van Tieghem, in the departments of microscopic anatomy and morphology, are

numerous and important. Considerable prominence is given to his well known view that the elements of a fibro-vascular bundle are differently arranged in the root, stem and leaf.

The new German edition gives evidence of thorough revision. Numerous slight changes in phraseology, greatly for the better, have been made throughout the book, and several chapters have been added. The most important of them are the following: Supplementary growth in thickness; alternation of generation; periodical movements of developing organs.

A change in arrangement which will provoke much adverse criticism is the new classification of the Cryptogamic plants. This re-arrangement is based partly on morphological and partly on physiological grounds, and brings into strange fellowship plants which have heretofore been placed in quite different orders, as the following synopsis will show:

First Group. THALLOPHYTES.

Class I. PROTOPHYTES.

Forms containing chlorophyll.—A. Cyanophyceæ.—B. Palmellaceæ.

Forms devoid of chlorophyll.—A. Schizomycetes.—B. Fermentation-fungi.

Class II. ZYGOSPOREÆ.

Forms containing chlorophyll.—A. Volvocineæ.—B. Conjugatæ and Diatoms.

Forms devoid of chlorophyll.—A. Myxomycetes.—B. Zygomycetes.

Class III. OOSPOREÆ.

A. Sphæropleæ.—B. Cœloplastæ. Vaucheria, &c. Saprolegnia, Peronospora.—C. Œdogoniæ.—D. Fucaceæ.

Class IV. CARPOSPOREÆ.

Forms containing chlorophyll.—A. Coleochætæ.—B. Florideæ.—C. Characeæ.

Forms devoid of chlorophyll (or true Fungi.)—A. Ascomycetes.—B. Æcidiomycetes (Uredineæ.)—C. Basidiomycetes.

An examination of the foregoing synopsis will plainly show that Professor Sachs is largely influenced by the theory of descent. It is worth while to compare his views with those of Professor Fischer, as communicated by Dr. Brefeld (Lehrb., p. 248–9). After presenting a sketch of Fischer's new classification, Professor Sachs says: "Professor Fischer regards Fungi and Algæ as two completely separated series developing in parallel lines, while I assume that in each class Fungi have diverged as branches from the different types of Algæ.

In conclusion, the hope must be expressed that the forthcoming English translation of this admiriable work will be as worthy of honest praise as the French edition. G. L. G.

22. *Notice of some Fresh-Water and Terrestrial Rhizopods.*—Prof. LEIDY stated that among the amœboid forms noticed by him n the vicinity of Philadelphia, there was one especially remarkable or the comparatively enormous quantity of quartzose sand which it

swallowed with its food. The animal might be viewed as a bag of sand! It is a sluggish creature, and when at rest appears as an opaque white, spherical ball, ranging from $\frac{1}{8}$ to $\frac{3}{8}$ of a line in diameter. The animal moves slowly, first assuming an oval and then a clavate form. In the oval form one measured $\frac{3}{5}$ of a line long by $\frac{2}{5}$ of a line broad, and when it became clavate it was $\frac{2}{3}$ of a line long by $\frac{1}{8}$ of a line broad at the advanced thick end. Another, in the clavate form, measured $\frac{7}{8}$ of a line long by $\frac{1}{8}$ of a line wide at the thick end. The creature rolls or extends in advance, while it contracts behind. Unless under pressure it puts forth no pseudopods, and the granular entosarc usually follows closely on the limits of the extending ectosarc. Generally the animal drags after it a quantity of adherent dirt attached to a papillated or villous discoid projection of the body.

The contents of the animal, besides the granular matter and many globules of the entosarc, consists of diatoms, desmids, and confervæ, together with a larger proportion of angular particles of transparent and mostly colorless quartz. Treated with strong mineral acids so as to destroy all the soft parts, the animal leaves behind more than half its bulk of quartzose sand.

The species may be named AMŒBA SABULOSA, and is probably a member of the genus *Pelomyxa*, of Dr. Greef (Archiv f. Mik. Anat., x, 1873, 51).

The animal was first found on the muddy bottom of a pond, on Dr. George Smith's place in Upper Darby, Delaware County, but has been found also in ponds in New Jersey.

When the animal was first noticed with its multitude of sand particles, it suggested the probability that it might pertain to a stage of life of *Difflugia*, and that by the fixation of the quartz particles in the exterior, the case of the latter would be formed. This is conjectural and not confirmed by any observation.

A minute amœboid animal found on *Spirogyra* in a ditch at Cooper's Point, opposite Philadelphia, is of interesting character. The body is hemispherical, yellowish, and consists of a granular entosarc with a number of scattered and well-defined globules, besides a large contractile vesicle. From the body there extends a broad zone, which is colorless and so exceedingly delicate that it requires a power of 600 diameters to see it favorably. By this zone the animal glides over the surface. As delicate as it is, it evidently possesses a regular structure, though it was not resolved under the best powers of the microscope. The structure probably consists of globular granules of uniform size alternating with one another, so that the disk at times appears crossed by delicate lines, and at others as if finely and regularly punctated. The body of the animal measures from $\frac{1}{66}$ to $\frac{1}{50}$ of a line in diameter, and the zone is from $\frac{1}{333}$ to $\frac{1}{200}$ of a line wide. The species may be named AMŒBA ZONALIS.

The interesting researches of Prof. Richard Greef, of Marburg, published in the second volume of Scholtze's Archiv f. Mikrokopische Anatomie, on Amœbæ living in the earth (*Ueber einige*

in der Erde lebende Amœben, etc.), led me to look in similar positions for Rhizopods.

In the earth, about the roots of mosses growing in the crevices of the bricks of our city pavements, in damp places, besides finding several species of *Amœba*, together with abundance of the common wheel-animalcule, *Rotifer vulgaris*, I had the good fortune to discover a species of *Gromia*. I say good fortune, for it is with the utmost pleasure I have watched this curious creature for hours together. The genus was discovered and well described by Dujardin, from two species, one of which, *G. oviformis*, was found in the seas of France; the other, the *G. fluviatilis*, in the River Seine.

Imagine an animal, like one of our autumnal spiders, stationed at the center of its well-spread net; imagine every thread of this net to be a living extension of the animal, elongating, branching, and becoming confluent so as to form a most intricate net; and imagine every thread to exhibit actively moving currents of a viscid liquid both outward and inward, carrying along particles of food and dirt, and you have some idea of the general character of a *Gromia*.

The *Gromia* of our pavements is a spherical cream-colored body, about the $\frac{1}{15}$th of a line in diameter. When detached from its position and placed in water, in a few minutes it projects in all directions a most wonderful and intricate net. Along the threads of this net float minute Naviculæ from the neighborhood, like boats in the current of a stream, until reaching the central mass they are there swallowed. Particles of dirt are also collected from all directions and are accumulated around the animal, and when the accumulation is sufficient to protect it, the web is withdrawn and nothing apparently will again induce the animal to produce it.

From these observations we may suppose thet the GROMIA TERRICOLA, as I propose to name the species, during dry weather remains quiescent and concealed among accumulated dirt in the crevices of our pavements, but that in rains or wet weather the little creature puts forth its living net, which becomes so many avenues along which food is conveyed to the body. As the neighborhood becomes dry, the net is withdrawn to await another rain. The animal with its extended net can cover an area of nearly half a line in diameter. The threads of the net are less than the $\frac{1}{35000}$th of an inch in diameter.—*Proc. Acad. Nat. Sci. Phil.*, 1874, p. 88.

23. *Nature of the Sea-bottom.*—Prof. C. WYVILLE THOMSON has presented to the Royal Society a paper entitled Preliminary Notes on the nature of the Sea-bottom procured by the soundings of H. M. S. Challenger during her cruise in the Southern Sea in the early part of the year 1874, which are published in "Nature" for December and January. The following are extracts from it.

a. *Green-sand.* In the region of the Agulhas Bank, off the south extremity of Africa, from 98 and 150 fathoms, a greenish sand was brought up which was found to consist of casts of foraminifers in a glauconite-like material. The genera included Miliola,

Biloculina, Uvigerina, Planorbulina, Rotalia, Textularia, Bulimina and Nummulina, and, of much less abundance, Globigerina, Orbulina and Pulvinulina.

b. *Globigerina, gray and red ooze.* From Cape Agulhas to lat. 46° 16′, the greatest depth was 1,900 fathoms; and the bottom was Globigerina ooze, it consisting mostly of the shells of Globigerina, more or less broken, with a few of Pulvinulina and Orbulina.

The limit of the pure Globigerina ooze is near 2,250 fathoms. Passing to greater depths, the material of the bottom is first a "gray ooze," and then generally for all depths below 2,500 or 3,000 fathoms it is the "red ooze" or clay, which consists of a silicate of alumina and red oxide of iron. The transition is gradual, the shells first losing their sharpness of outline and becoming mixed with more or less of red-brown amorphous powder, which is so fine as to take days to settle. In the section between Teneriffe and St. Thomas, at the first four casts, the Globigerina ooze was obtained at depths from 1,525 to 2,220 fathoms; then at a depth of 2,740 fathoms, 500 miles from Teneriffe, and of 2,950 fathoms, 750 miles off, the ooze is gray but is largely the red clay mixed with some of the calcareous; and at 3,150 fathoms, 1,150 miles from Teneriffe, the bottom was a pure and smooth clay with scarcely a trace of lime. From this great depth the bottom rises, and the gray color and calcareous nature of the ooze returns, soundings in 2,050, 1900 and 1950 fathoms on the "Dolphin Rise" bringing up the Globigerina ooze. But passing from the middle plateau of the Atlantic into the western trough, where the depth is a little over 3,000 fathoms, the red clay returned in all its purity.

Prof. Thomson states that Mr. Murray, after a careful study of all the facts, has come to the conclusion, presented years ago by Professor Bailey, that the Rhizopods are not living in the deep ocean, but belong to the superficial waters. Facts prove that they are very abundant in these upper waters, that the shells have a perfection in the living state that is not found in the deep water specimens. With regard to the red ooze, which is almost destitute of life, the opinion is put forth that beyond a certain depth the shells of the Globigerinæ and other Rhizopods are dissolved, and that the alumina and iron which experiment has proved they contain are the source of the broad and barren regions of clay.

24. *Index to Volumes I to XIII of Observations on the Genus Unio*, together with descriptions of new species of the Family Unionidæ, and descriptions of new species of the Melanidæ, Paludinæ and Helicidæ, etc.; by Isaac Lea, LL D. Vol. III.—This is a supplementary Index to the previous Indexes published in 1867 and 1869, giving what was omitted in the others, references to anatomical and structural details, habits, etc.

25. *Reliquiæ Aquitanicæ*, being Contributions to the Archæology and Palæontology of Périgord and the adjoining Provinces of Southern France, by E. Lartet and H. Christy, edited by Thomas Rupert Jones, F.R.S., &c.—Part xv of this valuable work, for September, 1874, contains pages 205–224, 173 to 182, and Plate A xlii.

III. Astronomy.

1. *The Transit of Venus, December 8th.*—Telegrams announce successful observations of the Transit at Yokohama, Nagasaki, Vladivostock, Teheran, Cairo, Suez and Thebes, at points in India, China, Adelaide and Melbourne, and less perfect at Hobart Town. One hundred photographs are reported from India, and thirteen from that at Vladivostock. Failures are reported at Shanghai, and at the Russian stations of Omsk, Orenburg, Kasan, Uralsk, Astrachan, Kertch, and Tiflis. Twenty other Russian stations, Kerguelen's Land, the Sandwich Islands, Mauritius, and many other points, are yet to be heard from. The probabilities are that greater success has been attained, on the whole, than could reasonably have been expected, and that the successes have, in the main, been at the more important stations for determining the parallax.

IV. Miscellaneous Scientific Intelligence.

1. *Exploration in South America.*—Prof. Alexander Agassiz left the country near the close of November, on a trip to South America, especially to Chili and Bolivia. At Lake Titicaca he expects to dredge, besides making temperature observations. Mr. Garman, of the Museum of Comparative Zoology, accompanied him, and will go directly to Lake Titicaca to collect. Mr. Agassiz's health has been poor, since the great afflictions which befel him in the death of his father and, almost immediately after, that of his gifted wife. It is now somewhat improved, and it is believed that the journey will make the restoration complete.

2. *Observatory at Cordoba, Argentine Republic.*—Dr. B. A. Gould, the astronomer, after a brief visit to his home and friends at Boston, has left again for Cordoba, to resume his great work there with regard to the southern constellations, which is now far advanced toward completion.

3. *Cañons of the Colorado.*—Major J. W. Powell, the explorer of the Cañons of the Colorado, has a valuable article on the Colorado Basin and its Cañons in the January number of Scribner's Monthly. With the usual liberality of this excellent Monthly, the article is illustrated by many fine engravings, from the photographs taken by the artist of Powell's expedition.

4. *Statistical Atlas of the United States;* by Francis A. Walker. Authorized by the Act of Congress of March 3, 1873. —The great variety of valuable material locked up in a Census Report can be brought out for use only through laborious and critical study on the part of one who understands fully the philosophical bearing of the facts. Such a study has been made of the returns of the recent United States Census by Mr. Walker. His Statistical Atlas, Parts II. and III. of which have recently been published, presents to the eye the chief results arrived at, and attests, in every part, to the learning, judgment, and thoroughness of the author. By means of maps and diagrams the great facts in political and social science are made readily and impressively

intelligible in all their relations. Part II. embraces the department of *Social and Industrial Statistics.* The charts show, by colors, the growth of the United States in population from 1790, when the first census was taken, through eight decades to 1870; also the center of population for the different periods; the constituents of the population of each State at the present time; the distribution, absolute and relative, of the colored population; of foreigners and persons of foreign birth; as to illiteracy; also the distribution of wealth over the country; of public indebtedness; of taxation; of the most important crops; the relative amount of church and school accommodation; and so on. Part III. covers the *Vital Statistics*, and contains eighteen charts illustrating the distribution of population by age and sex; of native and foreign population; prevalence of various diseases for the two sexes, in different parts of the country and for the successive seasons of the year; relative birth rate; relative death rate for different diseases; relative number of blind, deaf, insane and idiotic persons, with the rate of increase or decrease for the decade from 1860 to 1870, and many other topics. The charts with reference to the blind and idiocy were prepared by F. H. Wines.

Part I, devoted to the *Physical Features of the United States*, is now in the press.

5. *Cave Hunting: Researches on the evidence of Caves respecting the early inhabitants of Europe*; by W. Boyd Dawkins, M.A., F.R.S., F.G.S., Curator of the Museum and Lecturer in Geology in the Owens College, Manchester. 456 pp. 8vo. Illustrated by a colored plate and many woodcuts. London, 1874. (Macmillan & Co.)—The author of this new volume on British and European Caves is one of the most prominent of British geologists, and one who has made a special study of the caves and the cave animals. The first and second chapters treat chiefly of the history of cave exploration, and the physical history of caves. Next follows chapters on the historic caves of Britain and their relics; caves used in the ages of Iron and Bronze; caves of the neolithic age; Range of æolithic dolicho-cephalic and brachy-cephalic men; Pleistocene caves of Germany and Great Britain; evidence from the cave inhabitants as to the Atlantic and Mediterranean coast line in the Pleistocene, illustrated by a map; the European climate in the Pleistocene; and on the instruments and methods of cave-hunting. Prof. Dawkins recognizes the existence of two Glacial eras in Great Britain: the older, or that commonly so called, one of greater elevation than now, was followed by an era of subsidence; and this by another era of elevation and glaciers, but of less extent of ice than in the first glacial era. The illustrations are numerous and excellent, and the work, while exact and thorough in its science, is popular in style and full of interest to all classes of readers.

Report of the Commissioner of Agriculture for 1873; 496 pp. 8vo. Washington. 1874.

Recent change of level on the Coast of Maine; by N. S. Shaler. 20 pp. 4to. From the Memoirs of the Boston N. H. Society. Volume II, Part 3, No. 3.

OBITUARY.

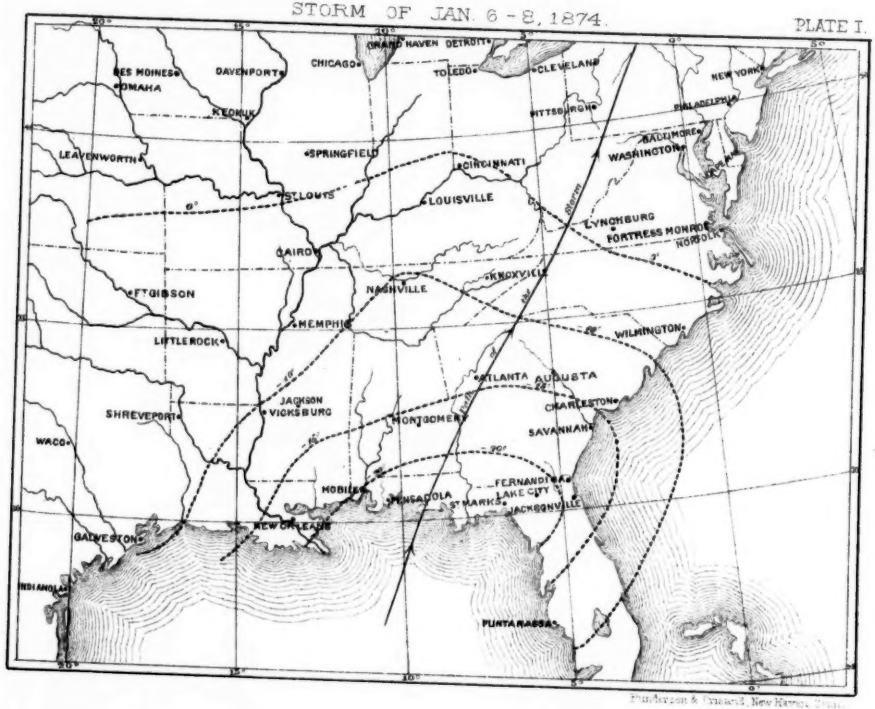
FRANCIS WALKER.—An exception to the precedent of speaking well of the dead is offered by the Entomologist's Monthly Magazine in its obituary notice of the late Francis Walker as an entomologist. And we who have written of Mr. Walker's work, after having examined his material in the British Museum Collection, can only endorse what is actually a repetition, in other words, of our statements in the Transactions of the American Entomological Society for July, 1868. With regard to the responsibility for the indifferent work in the British Museum lists, this lies, as the writer in the Entomologist's Monthly Magazine says, and as we had previously pointed out, with the authorities in the British Museum who authorized the publication of these lists. As their preface gives their authority, their publication is due to Mr. John Edward Gray, to whom science is so widely indebted that this error in judgment on his part must be condoned. For our part, from first to last, so far as our special branch is concerned, we have steadily opposed any total rejection of Mr. Walker's works as affording a bad precedent, and this contrary to the opinions of those yet eminent entomologists in whom we have learned to have confidence. At this moment, when a kind and amiable man has left us, we renew our appeal made in 1868, that Mr. Walker's material in the British Museum Collection be worked over by a competent hand. In this work reference should be had to the specimens and the descriptions, and every *tenable* name should be fixed, all doubtful names, founded on irrecognizable specimens, should be withdrawn, and in this way Mr. Walker's reputation would be saved from further obloquy, the ends of science furthered and the authorities of the British Museum atone amply for their mistake. Private collectors, who have Mr. Walker's types, would heartily join, doubtless, in a work which would be to their advantage, and a miserable scandal would be done away with forever. This, and so desirable a consummation, remains to be gained by the proper authorities of the institution which allowed the fault to be committed. What greater work have they in prospect that this duty shall be set aside? We close this paper with a kindly remembrance of the dead, and with the words we first used on the occasion of appearing as Mr. Walker's critic, "trusting that nothing we have ever said can be taken as reflecting personally upon a gentleman, whose courtesy and the extent of whose literary labors invite every consideration." A. R. GROTE.

EDWIN LANKESTER.—Dr. Lankester, well known for his zoological publications, died October 30th, at the age of sixty. He was elected a fellow of the Royal Society in 1845. For eighteen years he has edited, in conjunction with Mr. Busk, the Quarterly Journal of Microscopic Science.

Dr. THOMAS ANDERSON, late Professor of Chemistry in the University of Glasgow, died at Chiswick on the 2d of November. He was born in 1819.

SIR WILLIAM JARDINE, the zoologist, and especially distinguished for his labors in Ornithology, died at Sandown, in the Isle of Wight, on the 21st of November, aged 74.

STORM OF JAN. 6 - 8, 1874. PLATE I.



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